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# YMCA FITNESS ASSESSMENT: TOOL FOR EVALUATION WITH REGARDS TO ERGONOMICS

Jacob Havlovick

*Montana Tech of the University of Montana*

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# YMCA FITNESS ASSESSMENT: TOOL FOR EVALUATION WITH REGARDS TO ERGONOMICS

by  
Jacob Havlovick

A thesis submitted in partial fulfillment of the  
requirements for the degree of

Masters of Science in Industrial Hygiene

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## **Abstract**

Professional ergonomists have several methods to analyze lifting tasks, in which the main goal is to determine the amount of strain on the body during manual material handling tasks. Several physical characteristics have been used to determine lifting capabilities, but developed screening methods do not cover the necessary traits or the right number of traits to predict an accurate level of strain. This project examined the use of the YMCA Fitness Test Assessment as a possible screening tool to determine lifting performance.

The project had one objective; To determine the association of any physical characteristic that might be used to predict performance during lifting tasks, with proper form, using the Military Standard 1472G (Department of Defense Design Criteria Standard, 2012).

Approved by the Institutional Review Board by Montana State University, students volunteered to participate in the study, signing several documents for screening and testing. Participants signed a consent form, physical activity questionnaire, and health questionnaire to determine their health status. After screening the volunteers participated in basic body measurements; including height, weight, blood pressure, and resting heart rate. The next step of the study was to perform the basic YMCA Fitness Assessment which included; body composition, maximum oxygen consumption, isometric leg strength, isometric leg endurance, and flexibility. The participants then performed a max lift and frequency lifts referencing the MLT-STD-1472

Results to satisfy the main objective indicated that heavier, short duration lifting tasks, a resting heart rate could predict the ability to lift heavier objects. The higher the resting heart rate, the less likely it is an individual can perform a lifting task safely. For lighter lifts occurring at a higher frequency for a brief period of time, it is most likely that better maximum oxygen consumption could predict the safety of individuals in lifting tasks. The results of the study are incomplete, and further investigations are required to validate the results. Any further progress on a similar study would require more data to further support the results of this study. The author suspects that more individuals, grip strength, and better participation from the participants the YMCA Fitness Assessment test could be used as an analytical tool for performance in manual material handling tasks.

**Keywords: Psychophysical, Ergonomics, YMCA, MLT-STD-1472, Borg-RPE**

## **Dedication**

I would like to give thanks to my committee; the Safety, Health, and Industrial Hygiene faculty; and my family for continually being there to provide support and guidance while developing my thesis. I would like to thank Dr. Julie Hart and Dr. Roger Jensen on answering my almost endless questions and supporting my efforts. I would like to thank Theresa Stack for enlightening me about ergonomics and supporting me in understanding it. Lastly, I would like to thank John Amtmann and Dr. Bill Spath for teaching me about health and its association with the occupational industry.

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## Glossary of Terms

<b>Term</b>	<b>Definition</b>
American Conference of Governmental Industrial Hygienists (ACGIH)	U.S. government agency that establishes and recommends occupational exposure limits for chemical substances and physical agents. These limits are followed also in several other countries.
Department of Defense (DoD)	The department of defense is responsible for safeguarding national security of the United States; created in 1947.
Manual Material Handling (MMH)	The involvement of any type of manipulation of an object or load.
Maximum Acceptable Weight Limit (MAWL)	A situation in which an individual adjusts the weight of a load to the maximum amount that they feel they can sustain without strain or discomfort and without becoming unusually tired or out of breath.
Military Standard 1472G (MLT-STD 1472G)	A document that establishes uniform engineering and technical requirements for military-unique or substantially modified commercial processes, procedures, practices, and methods. There are five types of defense standards: interface standards, design criteria standards, manufacturing process standards, standard practices, and test method standards.
National Institute for Occupational Safety and Health (NIOSH)	Public health service organization established under the US Department of Health and Human Services (DHHS). Its activities include testing and certification of respiratory protective devices and air-sampling detector tubes, and recommendation for occupational exposure limits for various substances.
Occupational Safety and Health Administration (OSHA)	OSHA is a federal organization, part of the Department of Labor, which ensures safe and healthy working conditions for Americans by enforcing standards and providing workplace safety training.
Psychophysics	The branch of psychology that deals with the relationship between physical stimuli and mental phenomena.
Predictive	Relating to or having the effect of predicting an event or result.
Young Men's Christian Association (YMCA)	A welfare movement that began in London in 1844 and now has branches all over the world.

# 1. Introduction

## 1.1. Lifting in Industrial Hygiene

In industries today there are fewer back injuries as compared to the 1980's and early 1990's, but according to the National Safety Council (NSC) the back is the body part most frequently injured. Roughly 22% of 1.7 million injuries occurring in 1990 and decreasing annually are classified as back injuries (National Safety Council (NSC), 1991). The most common causes of back injuries are overexertion, awkward motions, or twisting and bending. The majority of back injuries do not occur from an acute injury, but rather for an extended period of time also known as chronic exposure, of awkward postures and motions with repetitive lifts or loading.

Roughly at least 27% of all industrial back injuries are caused by some form of lifting or some manual lifting task, or material handling (Bush, 2012). Most of the industrial back injuries are the result of performing continual lifting tasks lasting several months or years.

The handling of materials involves the manipulation of any object or load resulting in the displacement of an object. The physical characteristics of an object or load can vary; it can be large, small, conforming in shape, nonconforming, smooth; or it may have corners and edges. The object may also have handles allowing for an individual to have a grip on the object. It can be argued the natural or normal movements of humans and animals can be associated with some form of material handling.

The assessment of a physical load can be done by numerous methods to analyze human performance of the material handling tasks. Some methods of analysis include observational analysis, theoretical mathematical models, known databases of reference materials, and predictive software. The identification of the variables used in these analysis methods can be

separated into two distinct groups; psychological and physiological methods. By using the given methods, an analysis or review of the material can be used to predict or identify a physical trait which can be used as a screening tool to prevent muscular strain based on the given data. This study will be classified as a pilot study and will identify if any of the physiological variables from the YMCA fitness assessment test that can be used to predict perceived exertion, enabling the use of the YMCA assessment as a screening tool to prevent the development of back injuries.

### **1.1.1. YMCA Fitness Assessment Test**

The purpose of the YMCA assessment test is to determine the physical health a person may have in comparison to the national average. Another function of the YMCA fitness assessment test serves to help the educational department find out the health status of their students nationally. By knowing the students' health, the Boards of Education may implement a food based program based on the level of physical activity the students are receiving, or implement fitness programs based on the test values from the YMCA and determine if there is a good or poor level of health using the YMCA subjective percentile charts. The general levels of health go from poor to excellent. For example, someone who completes a one mile run in a period of 8 minutes will have a good to average rating of cardiovascular health, but if the time exceeded 9 minutes the student would have a poor rating. A suggestion based on these outcomes is for the student to have more cardiorespiratory practice.

The YMCA fitness test needs the participants to know the basic and proper forms of the designated tests, such as lifting and strength testing, and what their goals are during testing. The reasoning that individuals need only these things is to prevent them from cheating or trying to beat someone else. Any excess knowledge the participants would have may create a bias in their results.

There are several components or smaller tests that contribute to the YMCA fitness test; on average there are three to four tests. In this study the participant's assessment consists of five physical tests. In this study the YMCA fitness test is to provide an evaluation method in which the participants can test their physical limits and be compared to a national average, the results of the tests would determine the limits of their abilities and percentile placement.

The YMCA test may also be used to identify any physiological conditions which might predict perceived exertion, a known psychophysical tool. To evaluate the physical capabilities of a person when lifting, the YMCA fitness assessment may be important. The reason for selecting the YMCA fitness assessment is to have multiple physical values that have been tested in other studies such as strength, weight, age, health, flexibility, muscular endurance, and maximum oxygen consumption. One exception, which is not part of the YMCA, is grip strength. Grip Strength has been used in previous lifting studies but due to its lack of presence in the YMCA it was not used. The pilot study, in comparison to the previous studies only using one of these physical traits, will use multiple values.

The YMCA test will encompass height, weight, blood pressure, heart rate, body composition, cardiorespiratory, leg strength, leg endurance, and flexibility. Generally all of these physical traits are difficult to use for predictive means of performance in manual material handling (MMH) tasks. Although the YMCA test may be used to identify physical variables for predicting performance in MMH tasks, none of the values individually have been used collectively or in a similar manner. This reason is why the YMCA fitness assessment test has been selected; it is the best suspected test or tool to identify any or the most physiological variables. Historically the YMCA fitness assessment was developed over time, all tests were designed for access to the masses at YMCA fitness facilities since the government became

concerned since World War II. A final development criterion was to allow for a lot of individuals to participate at the same time.

### **1.1.2. Body Composition**

The first variable of the YMCA fitness assessment test is body composition, or the density of body fat an individual may have. To identify subcutaneous body fat, the skinfold caliper method is used rather than other methods. The logic of using the skinfold caliper method is that the percentage of subcutaneous body fat is proportional to the total amount of body fat present on the body.

Roughly one-third of the body's total fat is found in the subcutaneous area or underneath the skin; therefore, it is possible to identify the concentration of body fat that is not subcutaneous allowing the total percentage of body fat to be calculated. The exact proportion of subcutaneous to total fat varies with sex, age, and race (AF, Heymsfield, & Lohman, 1996). The variation of proportions of subcutaneous fat by sex, age, and race leave different regression formulas to be used to predict the body's density or total weight of percent body fat. "Body composition determined from skinfold thickness measurements correlates well ( $r = 0.70-0.90$ ) with body composition determined by hydrodensitometry" (Heymsfield, 2005, p. 523). To isolate a specific regression formula a specific group was targeted males between the ages of 20-29.

Body fat percentage is known to be associated with certain types of cardiovascular and metabolic diseases. For example, body fat deposition in humans will vary mostly by sex. Males are more predisposed to deposit fat around their waist and chest. Women are more predisposed to deposit fat around their thighs and waist. An increased concentration of body fat can lead to muscular issues of the spine and back. Higher values of body fat density or body fat percentage

can lead to a predisposition to muscular injury of the spine and back (Thorpe, Florence, Howard, & Joski, 2005).

Some limitations of using skinfold caliper assessment to associate body fat percentage are unique to each study. Body composition is extremely dependent on the experience of the technician or investigator who is measuring the skinfolds. To avoid the error of misplacing the skinfold site requires proper training from a certified course. A secondary error from this type of measurement is the lack of practical experience the investigator may have with gathering accurate measurements. “The accuracy of predicting percent body fat from skinfolds is approximately +/- 3.5%, assuming appropriate techniques and equations have been used” (Heyward & Wagner, 2004, p. 268).

### **1.1.3. Maximum Oxygen Consumption**

The value of maximum oxygen consumption ( $VO_2\text{Max}$ ) refers to the amount of oxygen the body can utilize in a one-minute period. The  $VO_2\text{Max}$  value measures the body's ability to perform work under aerobic conditions; through various studies this value has been classified as a predictor of task endurance. Traditionally,  $VO_2\text{Max}$  has been used in athletics to predict length of time, such as cross-country runners, it has also been used in very physically intense jobs or tasks such as MMH over an 8-hour work day.

Occupationally the  $VO_2\text{Max}$  values used are approximated; this is due to the complex nature of gathering the  $VO_2\text{Max}$  values. The values, based on approximations, use only the employee's age and known physical condition. The reasoning the employers need to approximate the  $VO_2\text{Max}$  value is because the direct measurement of  $VO_2\text{Max}$  is not economically feasible. To compensate for the loss of an accurate reading a wide range of submaximal and maximal exercise tests are used to estimate  $VO_2\text{Max}$ .

The validity of the submaximal and maximal tests has been done by identifying the correlation between  $\text{VO}_2\text{Max}$  measured directly and the  $\text{VO}_2\text{Max}$  estimated using physiologic and known responses. Examples of physiological responses are heart rate, other known physical responses can be from tests such as the Cooper 12-minute test or 1.5 mile time. The Cooper 12-minute test is used to determine the amount of distance one covers in 12 minutes, while the 1.5 mile run/walk test is used to identify how long it will take to cover this distance.

The more common modes of testing use equipment such as cycle ergometers, treadmills, a field, or step tests are used to calculate  $\text{VO}_2\text{Max}$ . The equipment used depends on the setting available and the training of the tester. Based on the location, equipment, and the individual there are several disadvantages associated with these testing methods. The individuals who perform in the test may have a low aerobic capacity and they may not be fully motivated to work at their highest capacity. The level of fitness can have a major detrimental effect on individuals who have been sedentary or are generally out of shape. Another risk factor associated with general fitness are previous injuries that are cardiovascular or musculoskeletal in nature.

There are different uses of the found  $\text{VO}_2\text{Max}$ ; the first use includes the functional capacity of the heart. The second use  $\text{VO}_2\text{Max}$  has in physical conditioning is its association with cardiorespiratory fitness. The third use of  $\text{VO}_2\text{Max}$  is to identify if the person is susceptible to cardiorespiratory diseases or health conditions (Arena, et al., 2007).

#### **1.1.4. Isometric Leg Strength and Endurance**

The American College of Sports Medicine (ACSM) has created a unique term or configuration of muscular strength and endurance.



The ACSM has melded the terms muscular strength, endurance, and power into a category termed “muscular fitness” and included it as an integral portion of total health-related fitness in the position stand on the quantity and quality of exercise for developing and maintaining fitness (Garber, et al., 2011).

The amount of muscular contraction force a group of muscle fibers can produce is known as muscular strength. The muscle fibers ability to continually contract providing a force is known as muscular endurance. Lastly, muscular power is the muscle’s ability to exert a force for a period of time or a rate of power. Traditional methods of classifying lifts in muscular terms are the number of lifts less than or equal to 3 are targeting strength, repetitions of greater than or equal to 12 are considered muscular endurance.

Current epidemiologic data provides evidence of a relationship between back injuries and weak back strength in job tasks. A major concern in regards to the relationship between back injuries and weak back strength is the lack of a definition for a testing method identifying back strength. A study by (Chaffin & Park, 1973) found an increase in the rate back injuries of subjects doing tasks requiring strength that was greater than their isometric strength values. There are several common trends in regards to back strength and the risk of injury. A similar study by (Chaffin, Herrin, & Keyserling, An Updated Position, 1978) found a risk three times higher in subjects with a weaker back. Based on several studies there is contradictory or lack of supporting evidence for weaker back strength which can potentially lead to a greater risk of injury.

To test strength in regards to the back and legs several methods can be used. Three most common broad categories include: Isometric, dynamic, and psychophysical testing (Bush, 2012).

To test these methods several key components need to be taken into consideration to identify the right muscular contraction force: equipment, instructions, duration of measurement, length of rest period, posture, number of trials, physical condition, and subject motivation (Bush, 2012). In this pilot study the selected method for leg strength was to use the isometric testing method.

There are several concerns or criticisms related to isometric tests. A major concern with isometric testing is having a low association with dynamic motion, but the counter argument for this type of test is to create an ease of access to materials. A secondary precaution to isometric testing is to reduce the risk of back muscular strain by avoiding heavy weights exaggerating any muscular issues.

Some health benefits of maintaining a strong muscular build is healthy bone mass, glucose tolerance, musculotendinous integrity, and the ability to carry out activities of daily living. The activities of daily living and rate at which a person views their ability determine their quality of life and self-efficacy (Williams, et al., 2007). Maintaining the highest quality of life is one of the main goals of being physically fit.

#### **1.1.5. Flexibility**

It is well known that most Americans will suffer from low back pain at least once in their life. One possible cause is the flexibility of the back and hamstring muscles. Although it has never been documented, the Sit-and-Reach (SR) Test can be an indicator for the lack of flexibility for the lower-back extensors and hamstrings. Lack of flexibility has also been suspected of being associated with low-back pain. (Jackson, Morrow Jr., Brill, Kohl, Gordon, & Blair, 1998).

Contradictory to popular belief, any supporting evidence of flexibility as a health-related fitness component maybe inflated. The static flexibility tests do not appear to be associated with

reducing the risk of muscular back injuries (President's Council on Physical Fitness and Sports, 2000). Even though there is contradiction about the value of the flexibility exam, it is included because under normal conditions the flexibility test is a component of the YMCA fitness exam.

Significant evidence supporting the association between lower-back pain and the inflexible extension of hamstrings and the lower back is not clear (O'Conner, Hines, & Warner, 1996). Investigations regarding the identification of muscular flexion are mostly known for the hamstrings (Corbin & Pangrazi, 1992; Hui, Yuen, Morrow, & Jackson, 1999; Jackson & Baker, 1986; Jackson & Langford, 1989; Liemohn, Sharpe, & Wasserman, 1994; MacRae & Wright, 1969). Further evidence from these studies suggests flexibility is limited to not only the type of joint, but also the specific joint. An example of flexibility limitations is where one hip may be more flexible than the other.

The SR tests used to identify the level of flexibility one has, is more prevalent to the hamstrings, the tests could be used to stretch out the hamstrings, allowing for a more limber lifter. There are six common methods of performing the SR test which includes modifications of the: American Alliance for Health, Physical Education, Recreation and Dance. (American Alliance for Health, Physical Education, Recreation and Dance, 1980; American Alliance for Health, Physical Education, Recreation and Dance, 1985; American Alliance for Health, Physical Education, Recreation and Dance, 1988), YMCA, (Golding, 2000), Canadian, (Fitness and Lifestyle Research Institute, 1983), Wall, (Hoeger, 1989; Hoeger & Hopkins, 1992; Hoeger, Hopkins, Button, & Palmer, 1990), Back-Save (Cooper Institute for Aerobics Research, 1987), and the V-Sit SR Tests (Cooper Institute for Aerobics Research, 1987).

## 1.2. YMCA Fitness Assessment Test

Historically fitness has been a source of cultural influence dating all the way back to the ancient Greeks, covering areas for military importance after World Wars I and II. A support for fitness took a major increase in the 1950's when President Eisenhower got the results of fitness tests in regards to the children in comparison to European children, learning that 60% of children failed the test. As an effect, President Eisenhower formed the President's Council on Youth Fitness, and President's Citizens Advisory Committee on the Fitness of American Youth (Nieman, 1990). Now considering fitness is important for human performance and "ergonomics is the application of scientific principles and methods and data drawn from variety of disciplines" (Kroemer, 2006, p. 2), fitness is a major cornerstone of the YMCA and ergonomic goals in designing MMH tasks.

The main objective of any physical task requires an evaluation of what an employee can do, therefore using the YMCA test could be used to analyze physical health. The YMCA is one of the most widely known organizations around the world so using the YMCA testing criteria would enable employees to understand the testing criteria. The wide access to information in regards to the YMCA's testing methods would make testing requirements easier to understand and apply to preplacement screening considerations, without injuring employees. Since the ergonomic standard by Occupational Safety and Health Administration (OSHA) was rescinded March 8<sup>th</sup> 2001, the use of the YMCA test will not have a negative impact on the assessment and monitoring on how people will perform MMH tasks.

The original ergonomic standard was meant to provide guidelines and basic rules which needed to be reinforced in industries. Any ergonomic guidelines or methods of analysis are by voluntary basis because; no ergonomic rule or standard can be made to replace the rescinded standard. The use of adopting a replacement ergonomic guideline or method is left to a company,

but there may be exceptions by state. The old method is still available as a reference, many industries use some of the other methods, such as the military or the American Conference of governmental Industrial Hygienists (ACGIH) methods of lifting analysis.

### **1.3. Statement of the Problem**

The YMCA assessment test is widely applicable to multiple ages, ethnicities, and genders encompassing boys and girls from early childhood to elderly individuals of at least the age of 65. Based on the wide applicability of the YMCA test it can be used to evaluate individuals with regards to lifting performance. The online standards are the problem with ergonomic evaluations leaving no designated screening method. The limitations of applicable applicants for the study are rather limited, but no one is necessarily exempt from testing providing the necessary results which can be interpreted later on.

Fitness is not an exception to any individual; it can be applied to anyone who is not physically active and to those who are active daily. The practicality of fitness is not restricted to any one area of one's life either. Fitness is applied to one's personal life as well as ones professional life, in the professional field of fitness, it can vary widely. The demands are seen more frequently where the physical requirements are higher, as seen in laborers or any individual who has to move materials often or move materials that are noticeably heavier in weight.

To assess physical fitness there have been multiple tests; body composition, strength, endurance, flexibility, and cardiorespiratory. The purpose of these test are normally used to educate individuals about their present state of health/fitness and provide direction for fitness goals of tasks or of daily living. The normal uses of these tools can be used in other fields and industries, for the purpose of this pilot study these tests were used to identify physical limitations which may have a significant role in MMH tasks and during the evaluation of MMH

performance. A psychophysical tool can be used to examine the relationship between observed stimuli and physiological responses, allowing for the evaluation of those relationships and highlighting any anomalies which may exist.

Through analysis, any correlation between the testing values and perceived exertion may be used to identify if any of the physical values are predictive in perceived exertion in MMH tasks. By determining these values significance, the isolation of one or multiple values may be used to accurately determine the limitations of individuals in lifting tasks. Another target goal is to determine if testing may save time and money by identifying any physical limitations that are correlated to an increased rate of injury. Previous studies have not shown a strong indication of physical traits leading to physical limitations in lifting tasks.

To gather the required YMCA test data a designated distance, device to measure body fat, and a few pieces of lifting equipment are needed to find all the necessary physiological values. The YMCA test may be more in depth than traditional tests, which may have used one or two physical characteristics, but the YMCA test is bringing several values that may have some role in physical assessments.

During the assessment of personnel health, records are of high importance, the saying is “if it was not recorded it didn’t happen”. If health was not recorded a company may be held liable for the protection of a worker. Copies of these documents need to be provided due to a high level of legal concerns and assessment of health, which can be used to determine if any injuries occurred from a work-related condition. To assess the physical health concerns of participants in regard to their position a more unique testing method is required. The portability of this test was selected to reduce the amount of equipment required, and the tests were selected

for accessibility so individuals can do the tests in an environment free of specialized equipment. The YMCA fitness assessment tests selected are highly accessible and freely available.

Normal governmental bodies for assessment in ergonomic recommendations may include the ACGIH, Department of Defense (DoD), the National Institute for Occupational Safety and Health (NIOSH), and OSHA. ACGIH focuses on duration, frequency, and posture. The military standard is for extensive applications in human factors and ergonomics supporting the design of multiple military systems, usually the designs are for human occupancy. NIOSH focuses on ergonomic injuries in the workplace, industrial safety, and work stress. OSHA provides guidelines, regulations, and standards for general safety in occupational environments (Bush, 2012).

The military standard 1472 was originally developed in 1989 and its purpose was to refer to it for human factors and limitations in ergonomics, designing of equipment, and general issues in usability (Department of Defense, 2009). The DoD developed the standard and it is approved as a basic method of human design and engineering for their field of industry, including military work, environments, any systems, equipment, and personnel. Military Standard 1472 has been acknowledged worldwide as an authoritative source for human factors requirements and design criteria. The motivation for ergonomic research and applications should be strong given the potential of productivity increases, quality improvements, and cost savings as a result of ergonomically designed environments. (Bush, 2012).

As the military standard is known as a worldwide authoritative source on human factors, there should be some studies or investigation in the effectiveness of the military standard in regards to individuals and their physical limitations. A study by J. McDaniel, R. Shandis, and S. Madole they explored the physical strength and endurance criteria for assigning personnel to jobs

with a heavy physical demand, weight lifting and holding tests. The results show there is a wide range of abilities for people due to gender and physical strength variability (McDaniel, Skandis, & Madole, 1983).

Normal methods to assess lifting frequency and weight use the ACGIH criteria, which focus on the frequency of lifts per a unit of time. Other governmental bodies don't necessarily focus on the number of lifts or the weights of the objects. Due to the wide range of testing criteria and variables a process of elimination needs to be done for evaluation. Through process of elimination in accordance to availability and design, the best method to assess and associate a psychophysical tool is to use the military standard, which by most, is claimed to be the gold standard.

To target accessibility and affordability, with regards to the ergonomic standard and physical testing, the Military Standard 1472G was used and the YMCA fitness assessment was chosen. The governmental body that created the Military Standard 1472G, DoD, was targeting accessibility among the different services, a result of targeting this goal was also the availability to the public as well. The testing tool for this pilot study was the YMCA, originally intended to be available and beneficial to the public.

#### **1.4. Objectives**

This project has only one objective, to determine the association of physical characteristics measured by the YMCA test to the performance in lifting tasks using the military standard 1472G. To perform a study of this nature the Institutional Review Board gave approval for the study and the document for approval can be seen in appendix A. A more specific objective statement follows:



**Objective:** To determine the association of any physical characteristic that might be used to screen physical performance in lifting tasks with proper form, using the military ergonomic standard 1472G. The statistical test, Multiple Regression and General Linear Model, were used to identify the association of predictability between the physical traits and MLT-STD 1472G. The final results of the statistical analysis will allow for a proper screening method for placement in jobs to be developed.

### **1.5. Hypotheses**

By using the YMCA fitness test assessment, employers and employees will be informed of their physical status. Through testing and analyzing the results of this pilot study, employees may be alerted to their physical limit of how much weight they can lift. The basis of this is physical traits expressed in the YMCA test can be used to predict perceived exertion which are associated with maximum accepted weight limit (MAWL). The results of the test will determine the weight range of an object in which a person can move safely without exceeding the muscular force the back can generate, which if exceeded has been known to cause musculoskeletal injuries. Also, the employee will be alerted to their health status and receive recommendations to improve their physical condition.

The process for determining health status is done by performing the tests with the assessment set by the YMCA and comparing the results to a percentile table giving a subjective term of fitness. Other methods to determine physical fitness and lifting capacity are not fully developed or as encompassing. If an alternative method is sought out the tools will not be as suitable to determining an individual's lifting capacity in comparison to their given physical traits. To avoid this issue in the pilot study, the YMCA fitness assessment was selected.

The statistics to determine the predictive quality of perceived exertion from physical values was done using a multiple regression analysis, followed by a forward stepwise selection process. The purpose of this is to isolate physical values and determine if they are significantly associated with perceived exertion. Neither the null or alternative hypotheses are strong or weak in previous research supporting the claim of being a predictive tool of performance or perceived exertion. To test the main objective, after the multiple regression analysis, a forward selection stepwise function was used. The main assumption about all of the values is that they cannot predict exertion for the tests.

The first section is the maximum design weight lift.

- H<sub>0</sub> None of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Maximum Design Lift.
- H<sub>1</sub> Any or all of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Maximum Design Lift.

The second section is the one minute frequency weight lift.

- H<sub>0</sub> None of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Frequency Lift for 1 minute.
- H<sub>1</sub> Any or all of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Frequency Lift for 1 minute.

The third section is the two minute frequency weight lift.

- H<sub>0</sub> None of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat

composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Frequency Lift for 2 minutes.

- H Any or all of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Frequency Lift for 2 minutes.

The fourth section is the three minute frequency weight lift.

- H<sub>0</sub> None of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Frequency Lift for 3 minutes.
- H<sub>1</sub> Any or all of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Frequency Lift for 3 minutes.

## **2. Background**

### **2.1. Previous Results**

There have been numerous studies using one test to indicate lifting capacity or test used to show one physical test may affect lifting performance. No studies have been found to use multiple physical characteristics to predict perceived exertion on this scale. Any studies involving perceived exertion originate from MAWLs, this value comes from each person individually and does not conform to any standard. The value each person creates is from a weighed object that the person can handle for one workday without over exerting oneself. The level of physical development will change the MAWL each person can handle.

Any other options to identify perceived exertion from physical characteristics are either unknown or have no research supporting this process. Professional opinions based on perceived exertion originating from physical characteristics are suspected, but not necessarily expressed. For example, it is suspected the stronger you are the more you can lift therefore a lower perceived exertion should be expressed when compared to a less fit person. No proper test or analysis of results has been done using this method. If the testing gives a positive result for a correlation between physical characteristics and exertion, management and the associated safety and health department can use the psychophysical tool in a prevention program of back musculoskeletal injuries.

### **2.2. Studies of Lifting**

The YMCA fitness assessment has not been previously documented for use in ergonomics or assessment of lifting performance. Material handling can be documented as far back as the earliest civilization, although the study of human movement and material handling is more recent such as no earlier than the 1700's. The father of modern ergonomics, Fredrich

Taylor, may have started the development of the modern version with his fine motion studies, but it continues to grow to this day. The reason for ergonomic development is encompassed by the International Ergonomics Association (IEA) definition of ergonomics:

Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance (Bush, 2012).

To assess the movement of individuals and the association of materials there are two types of muscular movement. Dynamic; a rhythmic change of contraction and relaxation of the muscles, and static; a slow contraction with a heavy load or holding a position for long periods of time (Grandjean, 1977). MMH tasks movement and associated musculature can be classified as a dynamic contractive force. Previously mentioned, material handling is one of the most frequent and severe causes of muscular injury. The movement from material handling is not an isolated occurrence; it is seen all over the world. The main cause of the injuries is from overexertion. Overexertion is normally seen from lifting loads from abnormal lifting heights or a weight above the normal force of contraction the back can generate.

In a recent survey a variety of overexertion injuries have a rate of roughly 500,000 workers a year. This claim is equivalent to about 5 in every 100 workers. Over exertion is claimed to be a cause of lower back pain with over 60% of people suffering from this cause. Side effects of injury from overexertion may include lost work time if severe, less than a third of those injured will return to their original work (Bush, 2012).

The origin of overexertion is from humans manipulating a weighted object; it can cause a strain on the body and is exaggerated during stretching, bending, twisting, or straightening of the body parts involved in the lifting motion. The psychophysical tool of rate of perceived exertion (RPE) is commonly used to evaluate heart rate in cardiorespiratory tasks and muscular endurance. Lifting tasks could find use of an RPE scale for analysis, although there are two scales to choose from. The old Borg scale is from 6-20 and is representative of heart rate, while the newer scale is from 1-10 and is more subjective. Based on the information of the two scales the old Borg scale was used.

The normal assumption that a strain is caused during movement but a strain can happen during a static contraction. Other factors could be from slow or fast movements, and short or long tasks. Those who have experienced back pain describe it as a painful experience, frequently resulting in absence from work. Continual back pain without intervention may result in early disability development.

Everyone lifts at one point in their life, even if the weight varies from light weight objects, such as your keys, to a heavier object, such as a box full of household items. At one point in everyone's life they will experience a type of back pain. "The mere description of the problem of low back pain based on spatial characteristics of pain belies the complexity of the problem and its impact" (American College of Sports Medicine, 2013, p 211). Symptoms associated with back pain in general are misrepresenting the seriousness of issues whether the pain is acute or chronic in nature.

At some point in their lives, 60-85% of all Americans and Europeans will experience a bout of low back pain, ranging from a dull, annoying ache to intense prolonged pain. At

any one time, about 15% of adults have low-back pain, and it is the fifth most common reason for all physician visits (Nieman D. , 2011, p. 137).

The causes of back pain originally focus on injury causes of material handling ranging from bad posture, being overweight, lifting too much, lifting improperly, or even sleeping with a bad body posture.

Through evaluation or through the understanding in MMH tasks, one method of analysis for an individual, by ACGIH standards, may change considerably because of their unique physical characteristics. For example, height is used in ACGIH measurements and would deal with the anthropometric body measurements and the anthropometric values can vary considerably, so there are multiple physical traits that need to be taken into consideration in the analysis of individuals.

The best lifting position comes from having the individual get down on one knee and bring the object as close as possible to the body to keep the object within the power zone, where the spine is close to neutral as possible. Raise the object using the shoulders and biceps to bring the object as close to the body while maintaining a straight back, then stand up, this is the procedure for proper lifting form as seen in Figure 1.



**Figure 1. Proper Lifting Form**

The reason to use this lifting procedure is to maintain a neutral spine and keep the load close to the body, both minimizing forces on the spine and may reduce injury risk. By making small adjustments to lifting posture there is an increased possibility of reducing the development of musculoskeletal disorders. A conclusion can be drawn, by reducing the development of strain



and musculoskeletal disorders on the back, the individual will have a reduced perceived exertion in MMH tasks.

A major or well known cause or suspected cause of back injury in MMH tasks is physical activity, the lack of physical activity has the potential to increase the susceptibility of injury and its' after effects of injury development. Potentially increasing physical activity to support muscular strength and endurance and other physical factors may reduce the probability of injury development. Recent studies involving construction workers found that, more frequent leisure time were related to healthy lower backs (Holmstrom, Lindell, & Moritz, 1991) and severe low-back pain was related to less leisure time activity (Holmstrom, Lindell, & Moritz, 1992). Holmstrom stated the increased time for the reduction of muscular fatigue promotes a healthier back but some have stated that physical activity can reduce musculoskeletal systems and may be used as a treatment method. NIOSH stated that people with high aerobic capacity may be more fit for jobs that require high oxygen uptake, but will not necessarily be more fit for jobs that require high static and dynamic strengths and vice versa (Bush, 2012). Although it is debatable, physical activity has a positive or negative influence on musculoskeletal symptoms this could just be a minor contribution. Another consideration is the frequency of material handling; technology in many industries has reduced the amount of lifting by personnel. Heavier tasks are occasionally being left to mechanical or robotic engineering, so engineering has possibly altered the frequency of required MMH that may affect the development of musculoskeletal diseases over a lifetime.

To reiterate, in occupational industries any muscular movement is categorized into two groups as either dynamic or static movement, and is applicable to muscles as well. The dynamic muscular work involves coordination of multiple muscle groups to contract simultaneously at

certain electrical thresholds to allow for working movement. This is done to accomplish a goal or a task. Muscular contractions require oxygenated blood and nutrients. The more developed the muscle or the concentration of muscle fibers, allows for muscular contractions to last longer and have a higher oxygen consumption increasing the endurance time for handling tasks. Most material handling tasks involve a dynamic form of contraction, such as going up stairs or the movement of the arms. A static movement or handling task is similar, but without the form of movement. Static loading is seen mostly in every job such as holding an item. An example would be a hand holding a box, without necessarily moving the musculature.

A major concern in material handling over an extended period of time is muscular fatigue; performance and muscular fatigue have an inverse relationship. The lower the performance the higher the muscular fatigue. The amount of time an individual can sustain handling tasks is dependent on intensity, level of fitness, and environmental factors such as location. All three of these have an inverse relationship with performance during material handling tasks. A method to alleviate the chance of developing an injury is to allow for a resting period, to rest or refresh one physically. In a study supporting the findings the results found that for a participant to maintain an 8 hour work shift, the task should not average more than 33% of the worker's maximum aerobic capacity for that task (Astrand & Rodahl, 1970).

Dynamic and static muscular movement both lead to fatigue over an extended period of time but will vary accordingly by intensity, fitness, and environmental factors. Static muscular contractions may result in several spinal and tissue injuries from chronic exposure to work conditions of this nature. Conditions include: arthritis, inflammation of the tendons, symptoms of arthrosis, muscle spasms, soreness, and intervertebral disc troubles (Bush, 2012).

The reasoning behind static work causing musculoskeletal injuries originate from built up pressure during compression cutting off blood circulation partially or totally leading to fatigue. Depending on the type of muscular work, static work can lead to fatigue quicker than dynamic work. The muscles need to rely on reserves of oxygenated blood and pyruvate for energy during static contraction. The restriction of blood flow from sustained contraction can result in lactic acid build up deteriorating the muscular tissue. In heavy material handling tasks, static muscular contraction will result in the compression of blood vessels preventing the circulation of blood. Any wastes generated during static compression, on the cellular level, will ultimately accumulate resulting in pain, fatigue, and muscle soreness. There are several methods to reduce muscular fatigue. Brief and intermittent or shifting of the load from one muscle group to another can be done to reduce the amount of exertion, fatigue, for certain postures. Several actions that will aggravate the severity of a task that can be done during work have been noted by Kroemer and Helander. Bending forward or sideways, holding or carrying loads in the arms, manipulation of the load so it is held above the shoulders or out horizontally, resting the body weight on one leg, standing in place for an extended period of time, pushing and pulling objects, tilting the head forward or backward for an extended period of time, raising the arms above the shoulders for an extended period of time, and exertion of force to balance the load (Bush, 2012).

During the early stages of designing a MMH task it is of an urgent nature that static muscular contractions during a task be avoided to reduce the early development of muscular fatigue. As an example; if a weight is held out extended from the body compared to being close to the body, the back will need to generate more force for contraction. Any material that is close to the body would be in the powerzone, where it is easier to handle heavier loads reducing the contractive force of the back. The muscular movement involved with material handling is the

main concern and origin of several musculoskeletal disorders, normally a disorder is originating from repeated exposure of improper form and muscular contractions, normally for an extended period of time.

The type of muscular contraction is relevant but both static and dynamic muscular movement is only a small portion of the hazards found with MMH. The generation of metabolic waste will result in muscular pain, and will spread to the soft tissues, ligaments, joints, and tendons. The injuries sustained by the musculature and joints are cumulative in nature, the necessary steps to reduce the severity of these injuries is to prevent it by identifying the causal factors.

Muscular stress develops two types of musculoskeletal problems: reversible and persistent. Symptoms of reversible pain include pain of wariness, short lived, and pain that is relieved as soon as the weight is removed. Symptoms of persistent pain include localized strain and effects on the soft tissue, the pain does not disappear when the weight is removed and may interfere with non-work activities (Bush, 2012).

Disturbances from musculoskeletal tissue, which persists for years, may lead to inflammation of tendons and their sheaths. If the disturbances develop early on it may lead to malformation of joints, but generally if pain and discomfort is experienced, after development the musculoskeletal disturbances will cause deformation to the joints. Any inflammation or deformation may lead to irreversible disabilities. Epidemiological data supporting the evidence of chronic exposure to musculoskeletal disturbances, primarily static contractions, may lead to the following disabilities: Tendinitis, tenosynovitis, inflammation of origin and insertion tendons of muscles, arthrosis, muscle spasms, sprains, strains, arthritis, and problems with ones intervertebral discs (Bush, 2012).

If any of these symptoms develop, the person experiencing them needs to seek medical attention. Even though the development of these injuries may not occur in the occupational setting, they will affect overall performance. If the pain is ignored it can lead to permanent damage. Normally these symptoms are seen in static muscular contractions, and may be permissible for short periods of time, but one of the main goals of ergonomics is to reduce the frequency and/or duration of exposure.

The reduction in frequency, duration, and weight will reduce the strain on the musculature of the body. If these were not reduced or modified the individual who experiences pain related musculoskeletal injury could have permanent damage. Proper prevention and recovery in lifting material requires a modified lifting technique and a proper resting period.

### **2.3. Health Effects of Bad Posture**

The American Heart Association (AHA) and the American College of Sports Medicine (ACSM) recommend, for a healthy lifestyle, a minimum of 30 minutes of moderate intensity exercise for 5 days a week. The recommendations by both associations are drawn from supporting data providing a link between physical activity and decreased rates of morbidity and mortality.

The recommended physical activity to reduce morbidity can be associated with physical labor. The amount of work involved with physical labor is normally associated with the classification of ones' profession. Someone whose job is considered blue collar will generally require more physically demanding jobs than a white collar job. A physical laborer would be required to lift heavier materials than a desk clerk. A physical laborer may have the greater number of opportunities to aggravate the muscles of the spine and the back. Although there is a

higher probability of back pain from physical labor, no one is exempt from creating an opportunity to cause back pain.

A sudden or unknown muscular motion may cause the back to contract abnormally or cause an unwanted reaction, resulting in pain. Epidemiological studies have shown that in the presence of known risk factors such as force, repetition, and awkward posture; the muscles, joints, tendons, blood vessels, and nerves are at risk for musculoskeletal disorders. Bones are not generally considered to be at risk of these disorders; however, repetitive tasks can be detrimental on the vertebrae of the spinal column. A common risk factor for spinal injury can be associated with the many different lifting postures, all of which can cause different muscular contractions or bending affecting the spinal column. The continual movement of abnormal bending in the spinal column results from awkward postures and may affect bodily organs as previously stated.

According to the Occupational Health and Safety Administration (OSHA), back pain, strain, or injury is the nation's number one workplace safety problem and preventing back injuries is a major workplace safety challenge. The Bureau of Labor Statistics stated recently that more than one million workers suffer back injuries each year, and back injuries account for one of every five workplace injuries and illnesses. All costs associated with low back pain, covering legal, medical, and compensations from private, public, and governmental sources the total amount per year is between \$50-\$100 billion per year (Guo, Tanaka, Halperin, & Cameron, 1999). Lifting for long periods of time runs a high risk of lower back injury whether it is a light or heavy weighted object. To avoid injury, the physical parameters of people are being studied to identify if there are testing or analytical methods that can determine one's predisposition to injury.

## 2.4. Analysis of Lifting Tasks

Lifting analysis is a powerful tool for assessing work activities and performance. The risk of musculoskeletal injury associated with poor postures can be a motivation to make improvements. To compare performance and perceived exertion is rather difficult by other governmental standards. The psychophysical tool of RPE is commonly used to evaluate heart rate in cardiorespiratory tasks and muscular endurance.

Common governmental bodies to assess lifting performance, not necessarily in quality but rather quantity, are ACGIH, NIOSH, and the military. ACGIH evaluates based on the weight of the object, the number of lifts, and the body dimensions of the individual. NIOSH takes into consideration the same values but uses stand vertical dimensions whereas ACGIH uses the stature of the individual. The military takes into consideration gender, weight of the object, and the number of repetitions. These three are very similar, but to assess if there are any commonalities, the military is used because it takes into consideration specific values. The other two take into consideration the anthropometric values of individuals and can vary widely in testing of groups.

The ACGIH would use threshold limit values (TLVs), NIOSH uses equations, the military uses weight and frequency to evaluate performance. In detail the MLT-STD uses posture, frequency, duration, teams, and weight to assess performance. All of the recommendations by the agencies would be used in a dynamic situation, such as the work environment, rather than a controlled one, a lab. To avoid misleading results or missing variables testing needs to take into consideration other factors that may not have been present during testing in a controlled environment. The only benefit of testing in a controlled environment is to isolate physical variables and test at optimum conditions. Lifting analysis is a very powerful tool, if interpreted correctly, can lead to perceived exertion in material handling in which to assess

work activity. The availability of assessing field techniques and screening workers is a considerably large goal for ergonomic practitioners since no screening method currently exists.

The previous lifting standards used to predict quantity rather than quality have their own unique characteristics, ACGIH would take into consideration each person but it does not relate perceived exertion from any physical characteristics. NIOSH does not consider anthropometric measurements, but generally repetition and weight. MLT-STD considers gender, there are limitations to repetition, but they are focused on a maximum weight for one repetition. The military standard was selected due the simplicity of its variables, such as weight and gender. The classification of weight by gender and number of people allows selecting participants easier. Roughly 84% of active duty enlisted personnel are males; therefore males were selected for this study (Department of Defense, 2013). The military standard tests would be the best test to identify RPE exertion because of its simplicity and gender specific requirements. This pilot study selected the military standard because of its standards such as weight, frequency and gender.

## **2.5. Requirements by MLT-STD**

The assessment of psychophysical tools in MMH for determining maximum lifting capabilities has been used in physiology and biomechanical research prior to this study. Psychophysical refers to the methodology in subjects performing lifts to determine the maximum levels of safe exertion based on the individuals' personal perspective exertion. Interpreting personal exertion is based on anchor points based on a defined scale. The execution of this method is dependent on the understanding and cooperation from the subject, expertise, history of the investigator, and the interpretation from both the subject and the investigator to ensure safety during and after the test, to accurately determine the results of the physical performance data.



One of the most widely utilized methods for establishing criteria for MMH tasks is the psychophysical approach (Mital, A., & Ayoub, 1993). The purpose of utilizing the psychophysical approach is to combine biomechanical and physiological stresses and produce a personal evaluation of perceived stress during a task. Normally this approach is done by allowing the participants to adjust the load or weight to an exertion level which the participant or individual feels they can sustain without causing any strains or discomfort on their musculature. The development of muscular strain or discomfort usually is allowed for a brief period, indicated by becoming tired or physically exhausted, but best avoided for an extended period of time. The results of a study in this nature produce a MAWL. This method may develop a perceived exertion similar to RPE but is the opposite of the main objective. If this method was done in reverse to change perceived exertion from a given weight, it can be used to identify any physical traits that may provide evidence of perceived exertion in a lifting task.

The testing methods may vary from the criteria that were identified, but a specific outcome is needed. Also, each testing format is unique to a lifting task and to each individual participant so the MLT-STD was used based on its wide applicability. One person may be stronger than another, if testing was done by an old standard or different ergonomic standard the person could have a different weight and the revised method would lead to a different perceived exertion.

Governmental bodies have no set regulation or standard for ergonomics, due to the previous one being rushed, since the old standard was rescinded. After the OSHA regulation was rescinded, any modification to an individual company's ergonomics program became voluntary; along with the other governmental regulations. The lack of regulation and reinforcement for

standards left screening and analysis open to suggestion and variations allowing for any standard to be used for this study.

Another reason the regulation was rescinded is due to the similarities of the bodies of regulating health and safety. NIOSH and OSHA were established by the Occupational Safety and Health Act in 1970 (US Department of Labor, 1970). Another similarity from OSHA affecting other bodies is the similarities of OSHA and ACGIH; both of these governmental bodies are pursuing safe and healthy working conditions: with ACGIH they focus on research, information, education, and training, while OSHA focuses on developing and enforcing workplace regulations (Bush, 2012). Identifying the potential hazard of MMH is another similarity, but OSHA and ACGIH have different regulations or suggestions on how to analyze form and performance.

The previously listed government agencies have been tasked with providing legislation, guidelines, and tools to support ergonomic applications and safety in the occupational environment. OSHA is responsible for the promulgation of standards. Aside from the few governmental bodies of influence, there are several private organizations which have made contributions to the available guidelines and standards made by the government. Other agencies that have influenced the occupational industries as well as other industries or areas of governmental supervision, primarily OSHA, do not necessarily have any authority. The other agencies or private organization impacting occupational safety legislation and guidelines are seen in Figure 2:

**Department of Defense: Military Standard (MLT-STD) 1472F, 1999**  
**Environmental Protection Agency**  
**Mining Enforcement Agency, and**  
**International Organization for Standardization: ISO9000 series**  
**Figure 2: Agencies**

Through the lacking requirement of an official standard, all ergonomic assessment standards available by ACGIH, NIOSH, and OSHA are voluntary. The standard which is simple to understand and use is the MLT-STD 1472G, hence the reason why it is so widely used. The standard only requires gender and a roughly estimated weight of an object. These criteria will allow for testing to occur quickly and be understood with little issue.

### **3. Materials and Methods**

#### **3.1. Materials**

In series, a variety of tools were used to gather the necessary data for height, weight, blood pressure, times for the Cooper 1.5 mile run/walk, isometric leg endurance, isometric leg strength, and flexibility tests. Height was measured by a GPM Swiss made adjustable height staff. Weight was calibrated using a Detecto scale, serial number 3PO44. Blood pressure used a standard adult cuff with a circumference of 26.1 to 40.9 centimeters made by the American Diagnostic Corporation. Body composition utilized a Lange Skinfold Caliper from Beta Technology Incorporated. PAT. NO. 3,008,239. A PRECOR treadmill was used to indicate the distance traveled and time using the distance traveled and time elapsed functions. A designated platform and tensiometer from “Lafayette Instrument Company”, model number 32526-9 were used to find isometric leg strength. To measure time for the isometric leg endurance test, a Timex, Ironman Triathlon model was used. Flexibility was performed on a “K-mart Do-it-Yourself Home Center” yard stick. The holding carton for weights varied and was calibrated for the lifting tasks with weights of 87 and 45 pounds. The weighted objects were placed on a modified counter space, which was raised to a height of 3 feet. The testing took place in the Health Physical Education Recreation Complex (HPER) complex on Montana Tech of the University of Montana Northern Campus. Lastly, after gathering all the data from the test, participants’ data was run through a statistical program Minitab 17.

#### **3.2. Procedures**

##### **3.2.1. Screening**

The participants were asked if they wished to participate in this pilot study, via a campus wide email. After giving their consent, the participants reserved a time slot for which they

performed the tasks included in this study. They were given an informed consent document (see Appendix B), which included the full details of the study, and asked to fill out the remaining documents necessary to stay in the study. The remaining documents the participants filled out were a Physical Activity Readiness Questionnaire (PAR-Q). The PARQ is a Canadian document and is seen as an adequate form for health evaluation; enough to screen individuals using the ACSM standards (see Appendix C). The final document for health screening was a unique health questionnaire (see Appendix D) to identify if any health problems existed for the participant, following the ACSM guidelines for evaluation.

### **3.3. YMCA Procedures**

The participants, after finishing their paperwork, got ready by removing their shoes. Before each subject was weighed the Detecto scale was calibrated to zero, and their height was measured using a GPM Swiss made adjustable height staff. Following height measurements the participants moved onto the weight scale to have their weight measured.

After the height and weight measurements blood pressure was taken using the adult standard sized cuff by the investigator. The blood pressure was found in two to three trials, in which the average was taken. After the blood pressure cuff had been removed the heart rate was found using the radial pulse on the individuals designated arm. Two to three fingers were be placed on the radial pulse and measured for 30 seconds, the found pulse would be multiplied by 2 to find beats per minute. After the pre-testing measurements the participants would put their shoes back on and be told they will be having three markers placed on the right side of their body. The first mark, for the chest skinfold, was placed perpendicular to a line between the nipple and armpit. The second mark was to be placed vertically 1–2 inches to the anatomical right of the umbilicus. The third site was half way between the hip and the knee. These sites were

measured in this cyclical order three times, for example the individual would have their chest measured, then their abdomen, and lastly their thigh. The reason being for the cyclical pattern is to allow the adipose tissue to recover lost water content after measurement.

After body composition, the individual was taken to the exercise room where they performed the Cooper 1.5 mile run/walk. The main objective was to complete the distance in the shortest amount of time possible; if they had any questions on how to use the treadmill they were shown how to use it properly. The grade of the treadmill was to be at 0% grade but the speed could change depending on the individuals pace at which to complete the Cooper 1.5 mile run/walk. After completing the Cooper 1.5 mile run/walk the individual was allowed to get a drink of water and rest before moving on to the next test, which was the Isometric Leg Strength Test.

The Isometric Leg Strength test begun after being fully rested, the procedure involved the participant being in the proper form with legs bent at a  $110^{\circ}$  angle with their palms facing them at shoulder width apart. They were facing forward and the cable was adjusted to their height. After the adjustment of the cable the individuals were told to straighten their legs generating the most force, without using their back. Also, they were told that they did not need to hold the isometric leg strength pull as long as they could, because the meter would stop at the highest amount of force generated. Three trials were performed in which the average of the last two trials was taken to have an accurate reading.

Proceeding the isometric leg strength test, after a brief resting period, an explanation on how to perform the isometric leg endurance test was given and the participant got ready to begin the test. The test consisted of one trial, in which the participant did a traditional wall sit where they follow a 90-90 rule. The individuals had their calves to their thighs form a  $90^{\circ}$  angle and

their thighs to their back form a 90° angle. Their hands were placed on the wall and have their feet shoulder width apart as seen in figure 2.



**Figure. 3: Wall Sit Position**

The participants were told to finish the test they need to sit down to rest and the time was stopped. The participants only needed to perform one trial on this test because fatigue is developing and will have longer lasting effects.

The previous components of the YMCA fitness assessment have enabled the individuals to be warmed up and limber for the next test, the flexibility test. The flexibility test begins with having the participant remove their shoes so the heels of the feet can be placed on a 15-inch marker, using a K-Mart Do-It-Yourself measuring yardstick. The personal investigator was trained in where the hands were to be placed and they would place their hands on the participant's knees to prevent buckling or sliding of the feet. The test was performed three times and the average of the last two was taken to find the average flexibility of the hamstring. The

individual was to have their hands overlap together and slide them along the yardstick; the values they would get were subtracted from the 15-inch mark to give a hamstring flexibility value for the statistical data.

### 3.4. Lifting Task Procedures

The lifting tasks were pre-planned. A faculty member demonstrated and provided photos of the proper lifting technique. The person got down on one knee and placed the knee as close as possible to the crate. Then the participant was to lift the object to waist or hip height, the participant could place it on their knee if they wished to, and proceed to standup. At standing height the participants placed the crate on an elevated platform and set it down. The participants were asked to give a perceived exertion using the old RPE Borg Scale (Borg, 1998). The scale can be from 1-10 or 6-20. In this study 6-20 was used, which is representative of heart rate as seen in Figure 3.

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very Hard
18	
19	Very, very hard
20	

**Figure 4: Old Borg RPE Scale**

The lift of 87 pounds allowed the participant to give a RPE for lifting the military standards maximum design lift up. Next the participant would do the same procedure, but in reverse, and placed the crate on the ground and give a perceived exertion for down. After



gathering the perceived exertions, using the Borg scale for up and down, a total RPE was asked for the lifting task encompassing the up and down portions from the participants.

### **3.5. Statistical Methods**

The statistical method for the prime objective used the multiple regression analysis, a test to indicate the level of significance for independent variables. Typically, this testing analysis is used on data sets of at least 25 data points used to predict a dependent variable. A p-value from the values indicates a level of significance. P-values greater than 0.50 have no significance, values greater than 0.2 have little significance, values greater than 0.05 have noticeable significance, and values less than 0.05 are statistically significant for predicting perceived exertion and linking it to physical values.

F values will also be listed in the results of the study, the F value will vary depending on the number of degree of freedom from the between and within groups during calculations. The results of each section will be discussed within each section.

## 4. Results

### 4.1. Objective Results

Results of the Multiple Regression analysis are in Table I. The values before any modification of a stepwise function, the variables include the  $R^2$  and  $R^2$  (adjusted) values for the targeted military lifting tasks.

**Table I: Multiple Regression  $R^2$  and  $R^2$  adjusted Values.**

	<b>MLT RPE Total</b>	<b>MLT RPE 1 Minute</b>	<b>MLT RPE 2 Minute</b>	<b>MLT RPE 3 Minute</b>
$R^2$ .	82.96%	74.19%	95.07%	95.74%
$R^2$ . adjusted	6.27%	0.00%	72.86%	76.57%

The  $R^2$  and  $R^2$  (adjusted) values explain the variability in values of the ANOVA tests, which are part of the multiple regression, forward stepwise functions. The results of the  $R^2$  values show a high percentage in explaining variability, a noticeable decline in explanation is in the MLT-RPE 1 minute section. The results indicate there is some missing information but it may not be a true indicator of perceived exertion leading to different results which may be used to screen individuals.

The testing values include a forward stepwise function for variability in a multiple regression analysis which is in Table II. The values include the  $R^2$  and the  $R^2$  (adjusted) for the military lifts.

**Table II: Multiple Regression  $R^2$  and  $R^2$  adjusted values forward selection.**

	<b>MLT RPE Total</b>	<b>MLT RPE 1 Minute</b>	<b>MLT RPE 2 Minute</b>	<b>MLT RPE 3 Minute</b>
$R^2$ .	28.76%	29.92%	85.85%	85.12%
$R^2$ . adjusted	21.63%	22.91%	74.05%	72.72%

The ANOVA values from each of the multiple regression analysis indicate there is a small but strong coverage of the variables to identify the perceived exertion in these designated

lifting tasks. The analysis of variance was performed to assess the level of significance from multiple physical values. The values were measured independently, or to isolate the proper value, to eliminate any interference from other values within the ANOVA test of the MLT-STD 1472G Maximum Design Lift Results.

#### 4.1.1. MLT-STD 1472G Maximum Design Lift Results

The results of the multiple regression analysis, with a forward stepwise function, for Maximum Design Lift are in Table III, showing the significant variables and their associated P-values, F-values,  $R^2$ , and  $R^2$  adjusted numbers.

**Table III: Multiple Regression, forward selection maximum design lifts Values.**

<b>MLT RPE Total</b>				
<b>Significant Variable</b>	<b>P-Value</b>	<b>F-Value</b>	<b><math>R^2</math></b>	<b><math>R^2</math> adjusted</b>
Height	0.072	4.04	28.76	21.63

The forward selection indicates the P-value of height in MLT-RPE total lift may be significant toward predicting perceived exertion, which may lead to limitations an individual may have. The F-Value of 4.04 with degrees of freedom at 1 and 11 show that the value is not truly significant, due to a required F-Value of 4.84 being significant at an alpha level of 0.05. To know the significant of height in relation to MMH more information needs to be available, which may cover the  $R^2$  and  $R^2$  adjusted values.

#### 4.1.2. MLT-STD 1472G Repetition Lifts 1 Minute Results

The results of the multiple regression analysis, with a forward stepwise function, for Repetition lifts for 1 minute are shown in Table IV, showing the significant variables and their associated P-values, F-values,  $R^2$ , and  $R^2$  adjusted numbers.

**Table IV: Multiple Regression, forward selection 1 minute repetition lifts Values.**

<b>MLT RPE 1 Minute</b>				
<b>Significant Variable</b>	<b>P-Value</b>	<b>F-Value</b>	<b>R<sup>2</sup></b>	<b>R<sup>2</sup> adjusted</b>
Leg Endurance Time	0.066	4.27	29.92	22.91

The forward selection indicates the P-value of leg endurance time in MLT-RPE frequency lift for 1 minute may be significant toward predicting perceived exertion, which may lead to limitations an individual may have. The F-Value of 4.27 with degrees of freedom at 1 and 11 show that the value is not truly significant, due to a required F-Value of 4.84 being significant at an alpha level of 0.05. To know the significant of height in relation to MMH more information needs to be available, which may cover the R<sup>2</sup> and R<sup>2</sup> adjusted values.

#### **4.1.3. MLT-STD 1472G Repetition Lifts 2 Minute Results**

The results of the multiple regression analysis, with a forward stepwise function, for Repetition lifts for 2 minutes are represented in Table V, showing the P-values, F-values, R<sup>2</sup>, and R<sup>2</sup> adjusted numbers of the significant variables respectively.

**Table V: Multiple Regression, forward selection 2 minute repetition lifts Values.**

<b>MLT RPE 1 Minute</b>				
<b>Significant Variable</b>	<b>P-Value</b>	<b>F-Value</b>	<b>R<sup>2</sup></b>	<b>R<sup>2</sup> adjusted</b>
Height	0.011	13.38	85.85	74.05
Weight	0.030	7.96		
Body Composition	0.190	2.19		
1.5 Mile Time	0.004	19.83		
Estimated VO <sub>2</sub>	0.006	16.99		

The forward stepwise function in the multiple regression analysis for frequency lifts at two minutes had several variables listed. The list of variables suggests there is not one true predictor

of perceived exertion leading to limitations of lifting, but several. The significant variables from the list, due to their P-Value and their F-Value meeting the requirement of exceeding 4.84, are height, weight, 1.5 Mile time, and Estimated VO<sub>2</sub>. Body composition didn't meet the requirements, but running it through the multiple regression analysis it is claimed to be significant. The R<sup>2</sup> and R<sup>2</sup> adjusted values are higher compared to the results of the earlier components, which indicates the test covers a lot of the information but some data is still missing. Overall, not one physical trait will predict perceived exertion resulting in a possible screening tool but these values may be tested for to identify if one may have a more difficult time performing MMH tasks.

#### 4.1.4. MLT-STD 1472G Repetition Lifts 3 Minute Results

The results of the multiple regression analysis, with a forward stepwise function, for Repetition lifts for 3 minutes are represented in Table VI, showing the P-values, F-values, R<sup>2</sup>, and R<sup>2</sup> adjusted numbers of the significant variables respectively.

**Table VI: Multiple Regression, forward selection 3 minute repetition lifts Values**

<b>MLT RPE 1 Minute</b>				
<b>Significant Variable</b>	<b>P-Value</b>	<b>F-Value</b>	<b>R<sup>2</sup></b>	<b>R<sup>2</sup> adjusted</b>
Height	0.013	12.37	85.12	72.72
Weight	0.079	4.48		
Body Composition	0.193	2.15		
1.5 Mile Time	0.007	15.93		
Estimated VO <sub>2</sub>	0.010	14.05		

The forward stepwise function in the multiple regression analysis for frequency lifts at three minutes had several variables listed. The list of variables suggests there is not one true predictor of perceived exertion leading to limitations of lifting, but several. The significant variables from the list, due to their P-Value and their F-Value meeting the requirement of exceeding 4.84, are

height, 1.5 Mile time, and Estimated  $\text{VO}_2$ . Body composition and weight didn't meet the requirements, but running it through the multiple regression analysis it is claimed to be significant. The  $R^2$  and  $R^2$  adjusted values are higher compared to the results of the maximum lift and the 1 minute frequency lifts, which indicates the test covers a lot of the information for a 3 minute interval of continual lifting but some information is still missing. Overall, not one physical value will predict perceived exertion resulting in a possible screening tool, but these values may be tested closely to identify if one may have a more difficult time performing MMH tasks.

## 5. Discussion

This discussion has four subsections to address the prime objective and two other sections encompassing the limitations and future work. The first four subsections restate the hypothetical objective and comments on the extent to which they were achieved.

### 5.1. Objective

The primary objective was to determine if any of the physical components of the YMCA fitness test can be used to predict perceived exertion and be used as a screening method based on physical values. The results of the study were interpreted from a multiple regression stepwise function. The statistical testing methods were done in series to identify if any physical values were consistent throughout testing. The stepwise function is a screening method that will remove any unnecessary physical variables to prevent compounding of less significant statistical data.

#### 5.1.1. MLT-STD 1472G Maximum Design Lift Results

First the research was to test the predictability of perceived exertion from lifting in regards to the MLT-STD 1472G Maximum design weight lift. The null hypothesis of the Maximum Design Lift was:

None of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Maximum Design Lift

The multiple regression analysis showed no significance to any of the values when they were compounded. In a stepwise function of the multiple regression analysis, the height of the participant was noticeably significant toward predicting perceived exertion. The F-Value shows

that height may be significant with more information, but right now it can be included in future work although it needs a further investigation to be certain. If the Maximum Design Weight Lift is to be the target of future studies, different physical traits need to be covered or investigated, due to the  $R^2$  and  $R^2$  adjusted values do not cover the test above 28% of the variability. Based on the results of this section the study has failed to reject the null hypothesis of the Maximum Design Lift.

### **5.1.2. MLT-STD 1472G Repetition Lifts 1 Minute Results**

The second subsection of this research was to test the predictability of perceived exertion from lifting frequency in regards to the MLT-STD 1472G modified weight lifts at 1 minute. The null hypothesis of the repetition lifts at 1 minute is:

None of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Frequency Lift for 1 minute.

The multiple regression analysis showed no significance to any of the values when they were compounded. In a stepwise function of the multiple regression analysis, the isometric leg endurance time of the participant was noticeably significant towards predicting perceived exertion. The F-Value shows that isometric leg strength may be significant with more information, but right now it can be included in future work although it needs a further investigation to be certain. If the Repetition Lifts 1 Minute is to be the target of future studies, different physical traits need to be covered or investigated, due to the  $R^2$  and  $R^2$  adjusted values do



not cover the test above 29% of the variability. Based on the results of this section the study has failed to reject the null hypothesis of the Repetition Lifts 1 Minute.

### **5.1.3. MLT-STD 1472G Repetition Lifts 2 Minute Results**

The third subsection of this research was to test the predictability of perceived exertion from lifting frequency in regards to the MLT-STD 1472G modified weight lifts at 2 minutes. The null hypothesis of this section is:

None of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Frequency Lift for 2 minutes.

The multiple regression analysis showed no significance to any of the values when they were compounded. In a stepwise function of the multiple regression analysis the height, weight, Cooper 1.5 mile time, and estimated oxygen consumption of the individual are significant towards predicting perceived exertion. Body composition was not eliminated during the forward selection, but has a P-Value and F-Value which cannot be classified as statistically significant but noticeable for future studies. The F-Value for the significant variables shows that height, weight, 1.5 Cooper mile time, and estimated  $VO_2$  are significant currently and with more information can be solidified as significant in studies, but right now it can be included in future work although it needs a further investigation to be certain. If the Repetition Lifts 2 Minutes is to be the target of future studies, different physical traits need to be covered or investigated, due to the  $R^2$  and  $R^2$  adjusted values do not cover the test above 85% of the variability. Based on the results of this section the study has failed to reject the null hypothesis of the Repetition Lifts 2 Minutes

in regards to the variables of resting heart rate, resting systolic and diastolic blood pressure, body fat composition, isometric leg strength, isometric leg muscular endurance, and flexibility.

Although, the alternative hypothesis has been accepted on the variables of height, weight, and maximum oxygen consumption which is also known as the 1.5 Cooper mile time and estimated  $\text{VO}_2$ .

#### **5.1.4. MLT-STD 1472G Repetition Lifts 3 Minute Results**

The fourth subsection of this research was to test the predictability of perceived exertion from lifting frequency in regards to the MLT-STD 1472G modified weight lifts at 3 minutes. The null hypothesis is:

None of the basic physical or YMCA fitness assessment physical values: which include height, weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, maximum oxygen consumption, isometric leg strength, isometric leg muscular endurance, and flexibility; significantly determine perceived exertion using the Military Standard 1472 Frequency Lift for 3 minutes.

The multiple regression analysis showed no significance to any of the values when they were compounded. In a stepwise function of the multiple regression analysis the height, Cooper 1.5 mile time, and estimated oxygen consumption of the individual are significant towards predicting perceived exertion. Weight and body composition were not eliminated during the forward selection, but they have a P-Value and F-Value which cannot be classified as statistically significant but noticeable for future studies. The F-Value for the significant variables shows that height, 1.5 Cooper mile time, and estimated  $\text{VO}_2$  are significant currently and with more information can be solidified as significant in studies, but right now it can be included in future work although it needs further investigation to be certain. If the Repetition Lifts 3 Minutes

is to be the target of future studies, different physical traits need to be covered or investigated, due to the  $R^2$  and  $R^2$  adjusted values do not cover the test above 85% of the variability. Based on the results of this section the study has failed to reject the null hypothesis of the Repetition Lifts 3 Minutes in regards to the variables of weight, resting heart rate, resting systolic and diastolic blood pressure, body fat composition, isometric leg strength, isometric leg muscular endurance, and flexibility. Although, the alternative hypothesis has been accepted on the variables of height and maximum oxygen consumption which is also known as the 1.5 Cooper mile time and estimated  $VO_2$ .

## **5.2. Study Limitations**

Minitab guidelines for multiple regression analysis and general linear modeling recommend having at least 25 sets of data points for analysis. The research had 12 data points for each of the YMCA values. Therefore, a limitation on the pilot study was using a smaller number of data points than were recommended by Minitab 17.

Measuring grip strength and incorporating body mass index (BMI) values are not basic components of the baseline measurements or YMCA tested values. The standards for BMI are convoluted for individuals who exercise regularly at moderate to high intensity. The reason for exclusion is because at the higher level of exercise and fitness muscle mass increases, increasing the body's density. The general population may have more accurate readings, but nearly all participants were more physically developed and may have skewed the results. In previous studies these values have been used and were relevant to lifting, so in future studies the BMI and grip strength need to be considered in evaluating lifting performance.

The last error that had affected the results was the effort on part of the participants. The test that was the greatest amount of effort, affecting the scores on  $VO_{2Max}$ , was the Cooper 1.5

mile run/walk test. It was recorded that the participants did not give their fullest commitment to this test. According to the ACSM going all out on the Cooper 1.5 mile run/walk is required, but most individuals do not know what that means, so participants will do it at a more relaxed pace.

### **5.3. Future Work**

The assessment of ergonomic performance from perceived exertion as a screening tool is not fully developed, leading to the understanding that development of a screening tool for ergonomic evaluation is stagnant. The lack of understanding has allowed the psychophysical tools, used in ergonomics, to have many flaws. In regards to the relationship of YMCA physical test values to perceived exertion in MMH tasks there are a few discrepancies in testing which needs to be further evaluated before a screening tool can be developed properly. The psychophysical tool needs to be changed to the Borg 10 scale for a more accurate reading of perceived exertion due to the old Borg scale of 6-20 being less significant to the study. The remodeling of the psychophysical tool will cause further work to be done to validate physical values in ergonomic lifting tasks.

During screening, individuals were screened immediately before they were tested, the group of volunteers should be evaluated all at once and screened and then they can be assigned testing times to avoid any conflicts of interest or the failure to identify any health, physical, or diseases which may be present.

Future work may include the grip strength and BMI values to assess other capabilities and limitations since they were not included in this study. In regards to the main physical testing a randomization of the tests should be done to avoid physical bias, to make certain it is irrelevant for the test itself to be significant. Other factors which may affect the understanding of perceived exertion from a MMH task would be to use more participants from a more diverse range of ages.

Through the lack of voluntary participants there needs to be more research done on how all the physical characteristics affect lifting performance.

#### **5.4. Conclusion**

By the using the International Ergonomic Association's definition of ergonomics, "understanding the interactions of humans and other elements of a system to optimize human well-being and overall safety performance," (Bush, 2012) the pilot study has met the requirements. The main objective of the study was to determine the association of physical characteristics that may be used to predict perceived exertion in MMH tasks to develop a screening tool for satisfactory applicants and to avoid strenuous activity on an individual's back.

In business, corporations, and tasks of daily lifting require lifting from time to time to move items of interest. The medical costs of back injuries from using improper lifting form are staggering and may be growing, but actions are being taken to reduce the severity or presence of the development of musculoskeletal injuries from MMH tasks. To assess employee's performance MAWL analysis has been done, but they identify what weight individuals are comfortable with over an 8-hour work day, to identify if a person may be more susceptible to injury a psychophysical tool combined with a physical analysis may provide evidence of limitations people may have in lifting jobs.

The study was to determine if the YMCA fitness assessment could be used for analyzing perceived exertion using a Borg scale, and linking the perception to a physical trait individuals may have. The significance of the physical value may be used as a screening tool in future work. Through the study there was a small group of participants which limited the results of the study reducing the significance of the test.

The results indicate that for heavier, short duration lifting tasks height may be used to predict the ability to lift heavier objects and screen individuals based on it. The shorter the person, the less likely an individual can perform a lifting task safely. For lighter lifts occurring at a higher frequency for a brief period of time, it is most likely that a better VO<sub>2</sub>Max could screen individuals and keep safety a top priority in lifting tasks.

The results of the study are incomplete, further investigations are required to allow for the results of the study to become valid. Any further progress on a similar study would require more data to further support the results of this study. Testing criteria may include more physical traits, such as grip strength, body mass index values, and randomization of testing may reduce the amount of variability in the results. Based on the results of this study the YMCA fitness assessment test, the information will account for most of the variability of the testing results, but no one specific value will predict the likelihood of a person developing physical injuries which may lead to the development of a screening tool to prevent musculoskeletal injuries of the back. In general, a more refined testing method isolating a few values may determine if an individual is more susceptible to injury, making the YMCA fitness test assessment too diverse, and with the selected values, too small to allow for the validity of the test to be accurate.

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## Appendix A: IRB Expedited Approval



### INSTITUTIONAL REVIEW BOARD for the Protection of Human Subjects in Research

FWA 00000078  
Research & Creative Scholarship  
University Hall 116  
University of Montana  
Missoula, MT 59812  
Phone 406-243-6672 | Fax 406-243-6330

**Date:** March 17, 2015

**To:** Jacob Havlovick - Safety, Health, and Industrial Hygiene, Montana Tech  
Bill Spath - Safety, Health, and Industrial Hygiene, Montana Tech

**From:** Paula A. Baker, IRB Chair and Manager

**RE:** IRB #74-15: "YMCA Fitness Assessment: Tool for Assessment of Ergonomic Lifts"

Your IRB proposal cited above has been **APPROVED** under **expedited review** by the Institutional Review Board in accordance with the Code of Federal Regulations, Part 46, section 110. Expedited approval refers to research activities that (1) present no more than minimal risk to human subjects, and (2) fit within the following category for expedited review as authorized by 45 CFR 46.110 and 21 CFR 56.110:

7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Each consent form and flyer used for this project must bear the dated and signed IRB stamp. Use the PDF sent with this approval notice as a "master" from which to make copies for the subjects.

**Amendments:** Any changes to the originally-approved protocol, including the addition of any new research team members, must be reviewed and approved by the IRB *before* being made (unless extremely minor). Requests must be submitted using [Form RA-110](#).

**Unanticipated or Adverse Events:** You are required to timely notify the IRB if any unanticipated or adverse events occur during the study, if you experience an increased risk to the participants, or if you have participants withdraw from the study or register complaints about the study. Use [Form RA-111](#).

**Continuation:** Federal and University of Montana IRB policy requires you to file an annual Continuation Report ([Form RA-109](#)) for expedited studies. You must file the report within 30 days *prior* to the expiration date, which is **March 16, 2016**. *Tip: Put a reminder on your calendar now.* A study that has expired is no longer in compliance with federal or University IRB policy, and all project work must cease immediately.

**Study Completion or Closure:** Finally, you are also required to file a Closure Report ([Form RA-109](#)) when the study is completed or if the study is abandoned. See the directions on the form.

Please contact the IRB office with any questions at (406) 243-6672 or email [irb@umontana.edu](mailto:irb@umontana.edu).

Form RA-108  
(Rev. 08/14)

**THE UNIVERSITY OF MONTANA-MISSOULA**  
Institutional Review Board (IRB)  
for the Protection of Human Subjects in Research  
CHECKLIST / APPLICATION

 IRB Protocol No.:  
74-15
MTTech

At the University of Montana (UM), the Institutional Review Board (IRB) is the institutional review body responsible for oversight of all research activities involving human subjects outlined in the U.S. Department of Health and Human Services' Office of Human Research Protection and the National Institutes of Health, Inclusion of Children Policy Implementation.

**Instructions:** A separate application form must be submitted for each project. IRB proposals are approved for no longer than one year and must be continued annually (unless Exempt). Faculty and students may email the completed form as a Word document to [IRB@umontana.edu](mailto:IRB@umontana.edu), or submit a hardcopy to the Office of the Vice President for Research & Creative Scholarship, University Hall 116. Student applications must be accompanied by email authorization by the supervising faculty member or a signed hard copy. *All fields must be completed. If an item does not apply to this project, write in: n/a.* Questions? Call the IRB office at 243-6672.

**1. Administrative Information**

Project Title: YMCA Fitness Assessment: Tool for Assessment of Ergonomic Lifts	
Principal Investigator: Jacob Havlovick	UM Position: Student
Department: Safety, Health, and Industrial Hygiene	Office location: N/A
Work Phone: N/A	Cell Phone: 208-681-0136

**2. Human Subjects Protection Training** (All researchers, including faculty supervisors for student projects, must have completed a self-study course on protection of human research subjects within the last three years and be able to supply the "Certificate(s) of Completion" upon request. If you need to add rows for more people, use the [Additional Researchers Addendum](#).)

All Research Team Members (list yourself first)	PI	CO-PI	Faculty Supervisor	Research Assistant	DATE COMPLETED Human Subjects Protection Course
Name: Jacob Havlovick Email: <a href="mailto:jhavlovick@mttech.edu">jhavlovick@mttech.edu</a>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2/26/2015 ✓
Name: Bill Spath Email: <a href="mailto:BSpath@mttech.edu">BSpath@mttech.edu</a>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	1/26/2015 ✓
Name: John Amtmann Email: <a href="mailto:JAmtmann@mttech.edu">JAmtmann@mttech.edu</a>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	1/16/2015 ✓
Name: Email:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

**3. Project Funding** (If federally funded, you must submit a copy of the abstract or Statement of Work.)

Is grant application currently under review at a grant funding agency? <input type="checkbox"/> Yes (If yes, cite sponsor on ICF if applicable) <input checked="" type="checkbox"/> No			Has grant proposal received approval and funding? <input type="checkbox"/> Yes (If yes, cite sponsor on ICF if applicable) <input type="checkbox"/> No	
Agency	Grant No.	Start Date	End Date	PI on grant

For UM-IRB Use Only

**IRB Determination:**

- ☐ Not Human Subjects Research  
☒ Approved by Exempt Review, Category # 4 (see memo)  
☒ Approved by Expedited Review, Category # 4 (see Note to PI)  
☐ Full IRB Determination  
☐ Approved (see Note to PI)  
☐ Conditional Approval (see memo) - IRB Chair Signature/Date: \_\_\_\_\_  
☐ Conditions Met (see Note to PI)  
☐ Resubmit Proposal (see memo)  
☐ Disapproved (see memo)

**Note to PI:** Non-exempt studies are approved for one year only. Use any attached IRB-approved forms (signed/dated) as "masters" when preparing copies. If continuing beyond the expiration date, a continuation report must be submitted. Notify the IRB if any significant changes or unanticipated events occur. When the study is completed, a closure report must be submitted. Failure to follow these directions constitutes non-compliance with UM policy.

Risk Level: Minimal
 Final Approval by IRB Chair/Manager: [Signature] Date: 3/17/2015 Expires: 3/16/2016



## Appendix B: Informed Consent

### SUBJECT INFORMATION AND INFORMED CONSENT

**Study Title:** YMCA Fitness Assessment: Tool for Assessment of Ergonomic Lifts

**Investigator(s):**

Principal Investigator:

Jacob R. Havlovick  
Montana Tech the University of Montana  
(208) 681-0136

Faculty Advisor

William Spath, Ph.D.  
HPER Building., Office 108  
(406) 496-4323

**Special Instructions to the potential subject:** This consent form may contain words that are new to you. If you read any words that are not clear to you, please ask the person who gave you this form to explain them to you.

**Purpose:** The purpose of this research study is to assess physical conditions of young adult males and determine if any of the related physical characteristics can be used as a predictive tool for ergonomic lifting performance.

**Procedures:** If you agree to take part in this research study, you will be given a Physical Activity Readiness Questionnaire (PAR-Q) and a medical questionnaire to determine whether you are ready for physical activity testing. A follow up YMCA fitness assessment exam will be given which may last up to 2 hours to complete participation in the study.

**Payment for Participation:** As an incentive for participating in this study, you may be compensated in an amount of \$10.00.

**Risks/Discomforts:** Use of weight lifting equipment and engaging in heavy body calisthenics may lead to musculoskeletal strains, pain and injury if adequate warm-up, gradual progression, and safety procedures are not followed. To minimize the amount of risk and discomfort a physical example will be provided and explained.

**Benefits:** Although you may not benefit from taking part in this study, your participation may help researcher better understand physical characteristics and limitations associated with proper ergonomic lifting.

**Confidentiality:** Your records will be kept private and will not be released without your consent. Your responses will be stored in a locked file drawer and will not be directly linked to your identify. Only the principal investigator, the faculty advisor, and research assistants will have access to the records.

**Compensation for Injury:** Although we believe that the risk of taking part in this study is minimal, the following liability statement is required in all University of Montana consent forms:

“In the event that you are injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by the negligence of the University of Montana or any of its employees, you may be entitled to reimbursement or compensation pursuant to the Comprehensive State Insurance Plan established by the Department of

<b>The University of Montana IRB</b>	
Expiration Date	<u>3-16-2016</u>
Date Approved	<u>3-17-2015</u>
Chair/Admin	<u>Philip J. O'Neil</u>

Administration under the authority of M.C.A., Title 2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University's Risk Manager (406-243-2700; [kathy.krebsbach@umontana.edu](mailto:kathy.krebsbach@umontana.edu)) or the Office of Legal Counsel (406-243-4742; [legalcounsel@umontana.edu](mailto:legalcounsel@umontana.edu)).” (Reviewed by University Legal Counsel, May 9, 2013)

**Voluntary Participation/Withdrawal:** Your decision to take part in this research study is entirely voluntary. You may refuse to participate or you may withdraw from the study at any time without penalty or loss of benefits to which you are normally entitled. You will be compensated in an amount of \$10.00.

You may be asked to leave the study for any of the following reasons:

1. Failure to follow the Project Director's instructions;
2. A serious adverse reaction which may require evaluation;
3. The Project Director thinks it is in the best interest of your health and welfare; or
4. The study is terminated.

**Questions:** If you have any questions about this study now or during the study, contact the Principal Investigator or the Faculty Supervisor listed with the phone number on the first page of this form. If you have any questions regarding your rights as a research subject, you may contact the the UM Institutional Review Board (IRB) at (406) 243-6672

**Statement of Your Consent:** I have read the above description of this research study. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions I may have will also be answered by a member of the research team. I voluntarily agree to take part in this study. I understand I will receive a copy of this consent form.

**Disclosure of Personal Health Information:**

I authorize Jacob R. Havlovick and the researcher's staff to use my individual health information for the purpose of conducting this research project. My individual health information that may be used to conduct this research includes:

- Medical History,
- Family History,
- Cigarette smoking habits, and
- Physical Activity Lifestyle

If I receive compensation for participating in this study, identifying information about me may be used as necessary to provide compensation.

\_\_\_\_\_  
Printed Name of Subject

\_\_\_\_\_  
Subject's Signature

\_\_\_\_\_  
Date

<b>The University of Montana IRB</b>	
Expiration Date	<u>3-16-2016</u>
Date Approved	<u>3-17-2015</u>
Chair/Admin	<u>[Signature]</u>

## Appendix C: PAR Q

Physical Activity Readiness  
Questionnaire - PAR-Q  
(revised 2002)

# PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
<input type="checkbox"/>	<input type="checkbox"/>	1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
<input type="checkbox"/>	<input type="checkbox"/>	2. Do you feel pain in your chest when you do physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	3. In the past month, have you had chest pain when you were not doing physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
<input type="checkbox"/>	<input type="checkbox"/>	5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
<input type="checkbox"/>	<input type="checkbox"/>	7. Do you know of any other reason why you should not do physical activity?

If  
you  
answered

### YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

### NO to all questions

- If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:
- start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
  - take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

#### DELAY BECOMING MUCH MORE ACTIVE:

- If you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
- If you are or may be pregnant — talk to your doctor before you start becoming more active.

**PLEASE NOTE:** If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

**Informed Use of the PAR-Q:** The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

**No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.**

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME \_\_\_\_\_

SIGNATURE \_\_\_\_\_

DATE \_\_\_\_\_

SIGNATURE OF PARENT  
or GUARDIAN (for participants under the age of majority) \_\_\_\_\_

WITNESS \_\_\_\_\_

**Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.**



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1:12

continued on other side...



## Appendix D: Health History Questionnaire

### Health History Questionnaire

Please answer the following questions to the best of your ability. For the following questions, unless otherwise indicated, circle the single best choice for each question. As is customary, all of your responses are completely confidential and may only be used in group summaries and/or reports. All information collected is subject to the Privacy Act of 1974. If you have any physical handicaps or limitations that would require special assistance with this questionnaire, please let your trainer know. This form is in accordance with the American College of Sports Medicine guidelines for risk stratification when followed correctly by your trainer. Your trainer should be certified with a national organization in order to use these forms correctly.

Name: \_\_\_\_\_ Ht.: \_\_\_\_\_ Wt.: \_\_\_\_\_

Gender: \_\_\_\_\_ Age: \_\_\_\_\_ Birthdate: \_\_\_\_\_

Address: \_\_\_\_\_

City: \_\_\_\_\_ State: \_\_\_\_\_ ZIP: \_\_\_\_\_ Phone: \_\_\_\_\_

Emergency Contact: \_\_\_\_\_ Phone: \_\_\_\_\_

Personal Physician: \_\_\_\_\_ Phone: \_\_\_\_\_

E-mail: \_\_\_\_\_

1. Have you ever had a definite or suspected heart attack or stroke? .....Yes No

2. Have you ever had coronary bypass surgery or any other type of heart surgery? .....Yes No

3. Do you have any other cardiovascular or pulmonary (lung) disease  
(**other than** asthma, allergies, or mitral valve prolapse)? .....Yes No

4. Do you have a history of: diabetes, thyroid, kidney, liver disease. ....Yes No  
(**circle all that apply**)

5. Have you ever been told by a health professional that you have had  
an abnormal resting or exercise (treadmill) electrocardiogram (EKG)? .....Yes No

6. If you answered YES to any of Questions 1 through 5, please describe:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

7. Do you currently have any of the following:
- |   |     |    |
|---|-----|----|
| a. pain or discomfort in the chest or surrounding areas that occurs when you engage in physical activity? ..... | Yes | No |
| b. shortness of breath .....  | Yes | No |
| c. unexplained dizziness or fainting .....  | Yes | No |
| d. difficulty breathing at night except in upright position .....   | Yes | No |
| e. swelling of the ankles (recurrent and unrelated to injury) .....   | Yes | No |
| f. heart palpitations (irregularity or racing of the heart on more than one occasion) .....                     | Yes | No |
| g. pain in the legs that causes you to stop walking (claudication) .....  | Yes | No |
| h. known heart murmur .....   | Yes | No |
| Have you discussed any of the above with your personal physician? .....   | Yes | No |
8. Are you pregnant or is it likely that you could be pregnant at this time? .....Yes No  
If yes, what is your expected due date? .....
9. Have you had surgery or been diagnosed with any disease in the past 3 months? .....Yes No  
If yes, please list date \_\_\_\_\_ and surgery/disease .....
10. Have you had high blood cholesterol or abnormal lipids within the past 12 months or are you taking medication to control your lipids? .....Yes No
11. Do you currently smoke cigarettes or have quit within the past 6 months? .....Yes No
12. Have your father or brother(s) had heart disease prior to age 55 OR mother or sister(s) had heart disease prior to age 65? .....Yes No
13. Within the past 12 months, has a health professional told you that you have high blood pressure (systolic  $\geq 140$  OR diastolic  $\geq 90$ )? .....Yes No
14. Currently, do you have high blood pressure or within the past 12 months, have you taken any medicines to control your blood pressure? .....Yes No
15. Have you ever been told by a health professional that you have a fasting blood glucose greater than or equal to 110 mg/dl? .....Yes No
16. Describe your regular physical activity or exercise program:
- type: \_\_\_\_\_
- frequency: \_\_\_\_\_ days per week
- duration: \_\_\_\_\_ minutes
- intensity: *low*      *moderate*      *high*      (circle one)
- BMI: \_\_\_\_\_
17. If you have answered YES to any of questions 7-16, please describe:
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_

18. Are you currently under any treatment for any blood clots? .....Yes No
19. Do you have problems with bones, joints, or muscles that may be aggravated with exercise? .....Yes No
20. Do you have any back/neck problems? .....Yes No
21. Have you been told by a health professional that you should not exercise? .....Yes No
22. Are you currently being treated for any other medical condition by a physician? .....Yes No
23. Are there any other conditions (mitral valve prolapse, epilepsy, history of rheumatic fever, asthma, cancer, anemia, hepatitis, etc.) that may **hinder** your ability to exercise? .....Yes No
24. During the past six months, have you experienced any **unexplained** weight loss or gain (greater than ten pounds for no known reason)? .....Yes No
25. If you have answered YES to any of questions 18-24, please describe:

---



---



---

26. Please list below all prescription and over-the-counter medications you are currently taking:

Medicine:	Reason for taking:	Dosage:	Amount/Frequency:
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

27. Are there any medicines that your physician has prescribed to you in the past 12 months which you are currently not taking? .....Yes No
- If so, please list:

---



---



---

I have answered the Health History Questionnaire questions accurately and completely. I understand that my medical history is a very important factor in the development of my fitness/wellness program. I understand that certain medical or physical conditions which are known to me, but that I do not disclose to my trainer, may result in serious injury to me. If any of the above conditions change, I will immediately inform my trainer of those changes. I, knowingly and willingly, assume all risks of injury resulting from my failure to disclose accurate, complete, and updated information in accordance with the attached questionnaire. I also understand that in order to properly risk stratify my Health History Questionnaire, my trainer should have a minimum of a national certification as a personal trainer. My trainer also verbally explained this statement to me to my understanding.

Client's Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Trainer's Signature: \_\_\_\_\_ Date: \_\_\_\_\_

### For Use by the Personal Trainer ONLY

Check the identified ACSM major coronary risk factors below:

<input type="checkbox"/> Lipids (TCH $\geq$ 200 OR HDL $<$ 35)	<input type="checkbox"/> Cigarette Smoking (or quit within the past 6 months)
<input type="checkbox"/> Family History	<input type="checkbox"/> High Blood Pressure/Blood Pressure Medications
<input type="checkbox"/> Diabetes/glucose $\geq$ 110 mg/dl	<input type="checkbox"/> Sedentary
<input type="checkbox"/> BMI $\geq$ 30	<input type="checkbox"/> Pregnancy
<input type="checkbox"/> Metabolic Disease	<input type="checkbox"/> Respiratory Disease (asthma, emphysema, chronic bronchitis)
<input type="checkbox"/> Signs or Symptoms of Cardiovascular Disease	
<input type="checkbox"/> Cardiovascular Disease	

#### Risk Stratification

☐ Apparently Healthy  
☐ Apparently Healthy Male  $\geq$  45; Female  $\geq$  55  
☐ High Risk, No Signs or Symptoms  
☐ High Risk, with Signs and Symptoms  
☐ Known Disease  
☐ Pregnancy

#### Factors

☐ One or No Risk Factors (No medical clearance required)  
☐ One or No Risk Factors (Initial medical clearance required)  
☐ Two or More Risk Factors (medical clearance required)  
☐ One or More Signs/Symptoms With or Without Risks (medical clearance required)  
☐ Diagnosed Cardiopulmonary/Metabolic Disease (annual medical clearance required)  
☐ Medical Clearance Required

**All clients needing written medical clearance from their personal physician must give it to their trainer prior to beginning their exercise program.**

Additional Comments: \_\_\_\_\_

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Page 4 of 4  
 revised 11/18/03  
 P04-020

**Health History Questionnaire** follows the American College of Sports Medicine recommendations for risk stratification. This must be performed on all clients in order to determine the need for medical clearance and/or exercise modifications. Any trainer or those making exercise recommendations should be certified in the proper use of the risk stratification process through a national organization.

If a client has a YES response to anything on page 1, he/she has KNOWN DISEASE, and must have medical clearance prior to beginning exercise.

If he/she has a YES response to anything on #7 a-h on page 2, your client is HIGH RISK WITH SIGNS/SYMPTOMS and must have medical clearance prior to exercise. If your client has a YES response to questions # 8 or 9, he/she must have medical clearance.

YES responses to two or more on questions 10-16 on page 2, your client is HIGH RISK WITHOUT SIGNS OR SYMPTOMS and must have medical clearance (unless he/she also has a YES answer in question #7 making them still HIGH RISK WITH SIGNS/SYMPTOMS).

All other questions on page 3 are at your own discretion. Remember, **when in doubt, refer out**. Please also refer to the most recent edition of *ACSM's Guidelines for Exercise Testing and Prescription* (Williams & Wilkins) as well as the most recent edition of the *ACE Personal Trainer Manual* (American Council on Exercise) for more explanations on the risk stratification. It is your responsibility as a trainer to remain updated on all changes or modifications for risk stratification in determining the need for medical clearance and exercise modifications/recommendations.

Thank you for using Premier Performance, Inc. Fitness Forms. Due to copyrights, you are not allowed to modify these forms in any way without the expressed written permission of Premier Performance, Inc. You are also not allowed, by law, to sell these forms or modifications thereof.

These forms have important legal consequences. An attorney should be consulted on all important matters including the preparation of legal forms or when you question the suitability of the form for your intended purpose. The American Council on Exercise® (ACE®) and Premier Performance, Inc. will not accept liability for any financial loss or damage in connection with the use of these forms. If you have further questions concerning preparation of these forms, please consult an attorney.

It is the responsibility of the trainer/fitness professional/etc. using these forms to use them appropriately. By using these forms, the purchaser/user of these forms agrees that he/she shall defend, indemnify and hold Premier Performance, Inc. and ACE harmless against any claims, liabilities, judgments, losses, costs and expenses, including reasonable attorney fees from claims by the purchaser/user or from third parties arising from the publication, distribution or sale of these forms. Premier Performance, Inc. and ACE will not be responsible for any injury, illness, etc. that may occur by those not qualified as fitness professionals as determined by a national organization such as ACE or ACSM, or by those who act in negligence. All procedures should follow the guidelines/standards as stated by ACSM or ACE in providing safe exercise recommendations.



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 Decatur, Georgia 30033  
 404-406-2873  
 pperform@bellsouth.net



American Council on Exercise  
 4851 Paramount Dr.  
 San Diego CA 92123  
 800-825-3636  
 www.ACEfitness.org



## Appendix E: Minitab outputs for Multiple Regression/ANOVA

### Regression Analysis: MLT RPE tota versus Height, Weight, Resting Hear, Diastolic bl, ...

Method

Categorical predictor coding (1, 0)

Forward Selection of Terms

$\alpha$  to enter = 0.25

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	11.79	11.791	4.04	0.072
Height	1	11.79	11.791	4.04	0.072
Error	10	29.21	2.921		
Total	11	41.00			

Model Summary

S	R-sq.	R-sq. (adj)	R-sq. (pred)
1.70906	28.76%	21.63%	0.00%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-19.9	16.1	-1.23	0.246	
Height	0.1818	0.0905	2.01	0.072	1.00

Regression Equation

MLT RPE total = -19.9 + 0.1818 Height

Fits and Diagnostics for Unusual Observations

	MLT RPE			Std	
Obs	total	Fit	Resid	Resid	
12	14.000	10.756	3.244	2.34	R

R Large residual

### Regression Analysis: MLT RPE 1 versus Height, Weight, Resting Hear, Diastolic bl, ...

Method

Categorical predictor coding (1, 0)

## Forward Selection of Terms

$\alpha$  to enter = 0.25

## Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	17.85	17.850	4.27	0.066
Leg Endurance Time	1	17.85	17.850	4.27	0.066
Error	10	41.82	4.182		
Total	11	59.67			

## Model Summary

S	R-sq.	R-sq. (adj)	R-sq. (pred)
2.04492	29.92%	22.91%	0.00%

## Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	13.12	1.70	7.73	0.000	
Leg Endurance Time	-3.47	1.68	-2.07	0.066	1.00

## Regression Equation

MLT RPE 1 = 13.12 - 3.47 Leg Endurance Time

## Fits and Diagnostics for Unusual Observations

Obs	MLT RPE 1	Fit	Resid	Std Resid	R
12	12.000	7.863	4.137	2.42	R

R Large residual

## Regression Analysis: MLT RPE 2 versus Height, Weight, Resting Hear, Diastolic bl, ...

## Method

Categorical predictor coding (1, 0)

## Forward Selection of Terms

$\alpha$  to enter = 0.25

## Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	5	91.570	18.314	7.28	0.016
Height	1	33.673	33.673	13.38	0.011
Weight	1	20.034	20.034	7.96	0.030
Body Composition	1	5.507	5.507	2.19	0.190
1.5 Mile Time	1	49.898	49.898	19.83	0.004

Estimated VO2	1	42.742	42.742	16.99	0.006
Error	6	15.097	2.516		
Total	11	106.667			

## Model Summary

S	R-sq.	R-sq. (adj)	R-sq. (pred)
1.58624	85.85%	74.05%	20.25%

## Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-108.2	25.7	-4.21	0.006	
Height	0.412	0.112	3.66	0.011	1.79
Weight	-0.0679	0.0241	-2.82	0.030	4.82
Body Composition	-0.257	0.174	-1.48	0.190	2.04
1.5 Mile Time	2.716	0.610	4.45	0.004	24.29
Estimated VO2	0.647	0.157	4.12	0.006	14.59

## Regression Equation

MLT RPE 2 = -108.2 + 0.412 Height - 0.0679 Weight - 0.257 Body Composition  
+ 2.716 1.5 Mile Time + 0.647 Estimated VO2

## Fits and Diagnostics for Unusual Observations

Obs	MLT RPE 2	Fit	Resid	Std Resid
12	13.00	10.74	2.26	2.24 R

R Large residual

## Regression Analysis: MLT RPE 3 versus Height, Weight, Resting Hear, Diastolic bl, ...

## Method

Categorical predictor coding (1, 0)

## Forward Selection of Terms

$\alpha$  to enter = 0.25

## Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	5	114.843	22.969	6.87	0.018
Height	1	41.395	41.395	12.37	0.013
Weight	1	14.978	14.978	4.48	0.079
Body Composition	1	7.178	7.178	2.15	0.193
1.5 Mile Time	1	53.304	53.304	15.93	0.007
Estimated VO2	1	47.004	47.004	14.05	0.010
Error	6	20.073	3.346		
Total	11	134.917			

## Model Summary

S	R-sq.	R-sq. (adj)	R-sq. (pred)
1.82909	85.12%	72.72%	20.19%

## Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-118.9	29.7	-4.01	0.007	
Height	0.456	0.130	3.52	0.013	1.79
Weight	-0.0587	0.0277	-2.12	0.079	4.82
Body Composition	-0.294	0.200	-1.46	0.193	2.04
1.5 Mile Time	2.807	0.703	3.99	0.007	24.29
Estimated VO2	0.679	0.181	3.75	0.010	14.59

## Regression Equation

MLT RPE 3 = -118.9 + 0.456 Height - 0.0587 Weight - 0.294 Body Composition  
+ 2.807 1.5 Mile Time + 0.679 Estimated VO2

## Fits and Diagnostics for Unusual Observations

Obs	MLT RPE 3	Fit	Resid	Std Resid	
12	14.00	11.59	2.41	2.07	R

R Large residual



## Appendix F: Minitab outputs for General Linear Model

### General Linear Model: MLT RPE tota versus Height, Weight, Resting Hear, Systolic Blo, ...

Method

Factor coding (-1, 0, +1)

Forward Selection of Terms

$\alpha$  to enter = 0.25

Factor Information

Factor	Type	Levels	Values
Resting Heart Rate	Fixed	8	48, 58, 60, 64, 74, 82, 84, 90

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Resting Heart Rate	7	37.500	5.3571	6.12	0.050
Error	4	3.500	0.8750		
Total	11	41.000			

Model Summary

S	R-sq.	R-sq. (adj)	R-sq. (pred)
0.935414	91.46%	76.52%	*

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	12.563	0.286	43.86	0.000	
Resting Heart Rate					
48	-0.563	0.859	-0.65	0.548	1.69
58	-0.063	0.640	-0.10	0.927	1.37
60	0.437	0.640	0.68	0.532	1.37
64	-2.062	0.640	-3.22	0.032	1.37
74	-2.562	0.859	-2.98	0.041	1.69
82	0.937	0.640	1.46	0.217	1.37
84	4.438	0.859	5.16	0.007	1.69

Regression Equation

MLT RPE total = 12.563 - 0.563 Resting Heart Rate\_48 - 0.063 Resting Heart Rate\_58  
 + 0.437 Resting Heart Rate\_60 - 2.062 Resting Heart Rate\_64  
 - 2.562 Resting Heart Rate\_74 + 0.937 Resting Heart Rate\_82  
 + 4.438 Resting Heart Rate\_84 - 0.563 Resting Heart Rate\_90

Fits and Diagnostics for Unusual Observations

	MLT RPE			Std	
Obs	total	Fit	Resid	Resid	
3	10.000	10.000	-0.000	*	X
4	17.000	17.000	0.000	*	X
8	12.000	12.000	0.000	*	X
10	12.000	12.000	-0.000	*	X

X Unusual X

## General Linear Model: MLT RPE 1 versus Height, Weight, Resting Hear, Systolic Blo, ...

Method

Factor coding (-1, 0, +1)

Forward Selection of Terms

$\alpha$  to enter = 0.25

Factor Information

Factor	Type	Levels	Values
Resting Heart Rate	Fixed	8	48, 58, 60, 64, 74, 82, 84, 90

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Resting Heart Rate	7	50.167	7.167	3.02	0.151
Error	4	9.500	2.375		
Total	11	59.667			

Model Summary

S	R-sq.	R-sq. (adj)	R-sq. (pred)
1.54110	84.08%	56.22%	*

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	9.938	0.472	21.06	0.000	
Resting Heart Rate					
48	0.06	1.42	0.04	0.967	1.69
58	-0.44	1.06	-0.41	0.700	1.37
60	1.56	1.06	1.48	0.213	1.37
64	-2.44	1.06	-2.31	0.082	1.37
74	-1.94	1.42	-1.37	0.243	1.69
82	0.06	1.06	0.06	0.956	1.37
84	5.06	1.42	3.58	0.023	1.69

Regression Equation

$$\begin{aligned} \text{MLT RPE 1} = & 9.938 + 0.06 \text{ Resting Heart Rate}_{48} - 0.44 \text{ Resting Heart Rate}_{58} \\ & + 1.56 \text{ Resting Heart Rate}_{60} - 2.44 \text{ Resting Heart Rate}_{64} \\ & - 1.94 \text{ Resting Heart Rate}_{74} + 0.06 \text{ Resting Heart Rate}_{82} \end{aligned}$$

+ 5.06 Resting Heart Rate\_84 - 1.94 Resting Heart Rate\_90

#### Fits and Diagnostics for Unusual Observations

Obs	MLT	RPE 1	Fit	Resid	Std Resid
3		8.00	8.00	0.00	* X
4		15.00	15.00	0.00	* X
8		8.00	8.00	0.00	* X
10		10.00	10.00	0.00	* X

X Unusual X

### General Linear Model: MLT RPE 2 versus Height, Weight, Resting Hear, Systolic Blo, ...

Method

Factor coding (-1, 0, +1)

Forward Selection of Terms

$\alpha$  to enter = 0.25

#### Factor Information

Factor	Type	Levels	Values
Estimated VO2	Fixed	9	27.2, 29.4, 30.7, 35.6, 39.7, 46.0, 50.2, 51.7, 61.7

#### Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Estimated VO2	8	97.500	12.188	3.99	0.141
Error	3	9.167	3.056		
Total	11	106.667			

#### Model Summary

S	R-sq.	R-sq. (adj)	R-sq. (pred)
1.74801	91.41%	68.49%	*

#### Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	11.204	0.544	20.61	0.000	
Estimated VO2					
27.2	4.13	1.04	3.96	0.029	1.31
29.4	3.80	1.63	2.32	0.103	1.75
30.7	-2.20	1.63	-1.35	0.270	1.75
35.6	-3.20	1.63	-1.96	0.145	1.75
39.7	-0.20	1.63	-0.12	0.909	1.75
46.0	-2.70	1.22	-2.22	0.113	1.42
50.2	-1.20	1.63	-0.74	0.515	1.75
51.7	-0.20	1.63	-0.12	0.909	1.75

## Regression Equation

MLT RPE 2 = 11.204 + 4.13 Estimated VO2\_27.2 + 3.80 Estimated VO2\_29.4  
 - 2.20 Estimated VO2\_30.7 - 3.20 Estimated VO2\_35.6 -  
 0.20 Estimated VO2\_39.7  
 - 2.70 Estimated VO2\_46.0 - 1.20 Estimated VO2\_50.2 -  
 0.20 Estimated VO2\_51.7  
 + 1.80 Estimated VO2\_61.7

## Fits and Diagnostics for Unusual Observations

Obs	MLT RPE 2	Fit	Resid	Std Resid
1	11.00	11.00	0.00	* X
2	10.00	10.00	0.00	* X
3	9.00	9.00	0.00	* X
5	15.00	15.00	0.00	* X
8	8.00	8.00	0.00	* X
10	11.00	11.00	0.00	* X
12	13.00	13.00	0.00	* X

X Unusual X

## General Linear Model: MLT RPE 3 versus Height, Weight, Resting Hear, Systolic Blo, ...

## Method

Factor coding (-1, 0, +1)

## Forward Selection of Terms

$\alpha$  to enter = 0.25

## Factor Information

Factor	Type	Levels	Values
Estimated VO2	Fixed	9	27.2, 29.4, 30.7, 35.6, 39.7, 46.0, 50.2, 51.7, 61.7

## Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Estimated VO2	8	125.750	15.719	5.14	0.103
Error	3	9.167	3.056		
Total	11	134.917			

## Model Summary

S	R-sq.	R-sq. (adj)	R-sq. (pred)
1.74801	93.21%	75.09%	*

## Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
------	------	---------	---------	---------	-----

Constant	12.315	0.544	22.65	0.000	
Estimated VO2					
27.2	5.02	1.04	4.81	0.017	1.31
29.4	3.69	1.63	2.25	0.109	1.75
30.7	-2.31	1.63	-1.42	0.252	1.75
35.6	-3.31	1.63	-2.03	0.136	1.75
39.7	-0.31	1.63	-0.19	0.860	1.75
46.0	-2.81	1.22	-2.31	0.104	1.42
50.2	-2.31	1.63	-1.42	0.252	1.75
51.7	0.69	1.63	0.42	0.703	1.75

#### Regression Equation

MLT RPE 3 = 12.315 + 5.02 Estimated VO2\_27.2 + 3.69 Estimated VO2\_29.4  
 - 2.31 Estimated VO2\_30.7 - 3.31 Estimated VO2\_35.6 -  
 0.31 Estimated VO2\_39.7  
 - 2.81 Estimated VO2\_46.0 - 2.31 Estimated VO2\_50.2  
 + 0.69 Estimated VO2\_51.7  
 + 1.69 Estimated VO2\_61.7

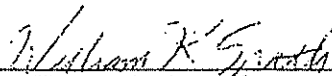
#### Fits and Diagnostics for Unusual Observations

Obs	MLT RPE 3	Fit	Resid	Std Resid	
1	13.00	13.00	-0.00	*	X
2	10.00	10.00	-0.00	*	X
3	10.00	10.00	-0.00	*	X
5	16.00	16.00	-0.00	*	X
8	9.00	9.00	-0.00	*	X
10	12.00	12.00	-0.00	*	X
12	14.00	14.00	0.00	*	X

X Unusual X

## SIGNATURE PAGE

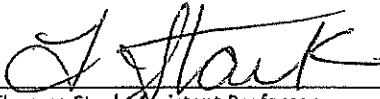
This is to certify that the thesis prepared by Jacob Ross Havlovick entitled "YMCA Fitness Assessment: Tool for Evaluation with Regards to Ergonomics" has been examined and approved for acceptance by the Department Safety, Health & Industrial Hygiene, Montana Tech of The University of Montana, on this 10th day of August, 2015.



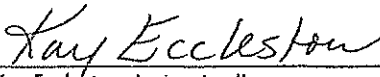
William Spath, PhD, Professor  
Safety Health & Industrial Hygiene Department  
Chair, Examination Committee



John Amtmann, Professor  
Safety Health & Industrial Hygiene Department  
Member, Examination Committee



Theresa Stack, Assistant Professor  
Safety Health & Industrial Hygiene Department  
Member, Examination Committee



Kay Eccleston, Instructor II  
Professional & Technical Communication Department  
Member, Examination Committee